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Starting A Container Nursery Business

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Alabama's Number One Agricultural Crop: Ornamentals

Ornamentals are a valuable part of Alabama's economy. The state's ornamental industry consists of flowering and foliage plants for interiors as well as trees, shrubs, groundcovers, and turfgrass. Sales from these plants reached $162 million in 1988. This represented an 18 percent increase from 1987 and an 80 percent increase from 1980. Ornamentals were the number-one agricultural crop in 1988, surpassing peanuts, cotton, and soybeans. Ornamentals are consistently one of the top three agricultural crops in the state. The statewide ornamentals industry has commercial operations listed in 64 of the 67 counties. About 350 nursery firms account for $75 million in annual sales. Container nurseries have increased consistently since 1980 with little increase in field production (Figures 1 and 2).

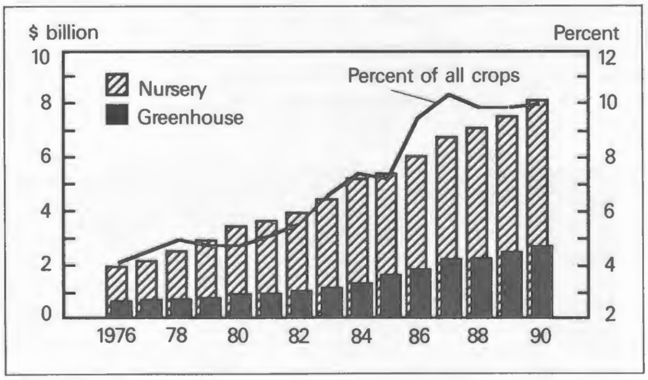


Figure 1. U.S. greenhouse/nursery grower cash receipts and percent of all crops.

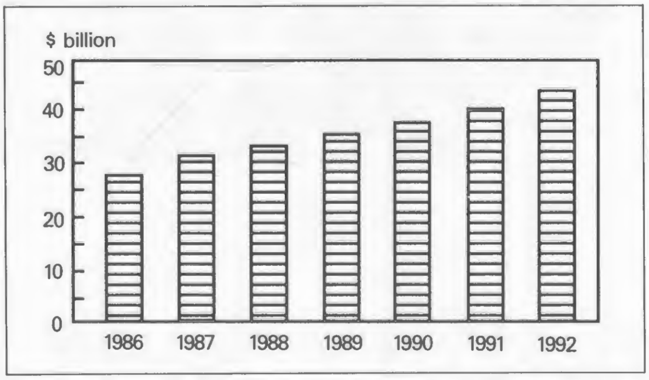


Figure 2. All greenhouse/nursery products: Value of U.S. consumer expenditures.

The largest container azalea production area in the world is in South Alabama.

Alabama's long growing season and mild climate offer ideal conditions to produce the properly selected plants in less time and at reduced production costs. This combination of technology and climate allows producers in this region to compete favorably in northern states.

Beginning In The Nursery Business

The nursery industry provides an exciting business career. The production of plants for profit has the potential of providing many personal and financial rewards. However, as with many other farming businesses that appear to be very simple on the surface, the nursery business is complex and requires a great deal of knowledge and skill not only in production but also in business and marketing practices. Invest your time studying books, bulletins, and trade magazines before deciding to invest money starting a nursery business. Visit with knowledgeable nursery producers and observe their layout, operations, and markets. If possible, spend time working at a successful nursery to get a feel for the timing, day-to-day activities, and production practices used in the nursery.

Production of nursery stock is both an art and a science. Many skills are best developed through observation followed by practice, not through reference books. To be a success in the nursery industry, you need to be self-motivated and able to manage time, people, space, materials, and money wisely, efficiently, and effectively. Very few individuals possess all these skills. As a good nursery producer, you must be able to realistically evaluate your own strengths and weaknesses and delegate weak areas to more competent individuals or obtain the services of consultants.

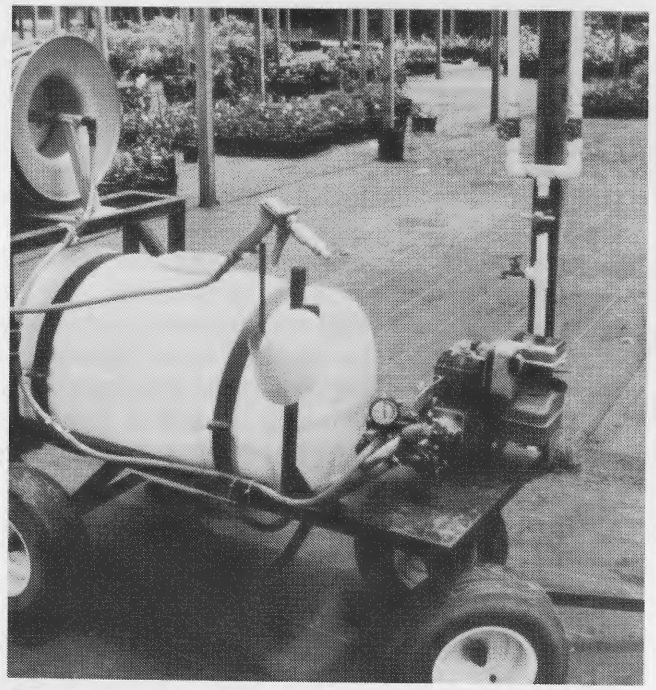
Most nursery beginners do not have the luxury of delegating. These people need to use all the available resources for help: Agricultural Extension Service, Small Business Administration, Alabama Nurserymen's Association, Soil Conservation Service, or any other resource that you can find. Help is available, if you make enough calls and if you are patient.

One crucial item that is often underestimated is the amount of money that is required to produce a salable plant. Knowing your production costs is very important. If you simply set your selling prices from other producers catalogs, you may be selling your plants below your cost. Listed on page 5 are the bottom-line figures for the production of various nursery crops produced in "typical" container nurseries with comparisons made on costs of production versus size of nursery. The container production figures are out-of-date (1986), but prices haven't gone down! You can take these figures and get a quick estimate of how much money it would take to produce 10,000 or 50,000 container plants. Notice the percentage of the total costs and you quickly see where most of the costs are in the production of nursery crops.

Another area that often baffles new container producers is the types of equipment required to produce a container plant. Listed below are some typical equipment and supplies used in a container nursery.

Examples Of Space, Equipment, Supplies, And Other Expenses Required By Most Container Nurseries

Containers.
Flats.
Media.
Media mixer.
Stakes and ties.
Tags, tape, ribbon, etc. . . .
Signs.
Fertilizer.
Injectors.
Spreaders.
Liners.
Insecticides.
Fungicides.
Herbicides.
Wetting agents.
pH adjusters.
pH meters.
Fencing.
Gravel.
Overwintering greenhouses.
Plastic.
Shade cloth and structures.
Irrigation (pipe, fittings, timers, pumps etc. . . .)
Conductivity meters.
Sprayers.
Computer and software.
Shovels, rakes, hoes, etc. . . .
Trucks and tractors.
Front-end loader.
Plant carts and trailers.
Cleaning equipment and trash cans.
Pruning equipment.
Knives.
Resource books.
Business supplies (forms, paper, staplers, pens, etc. . . .)
Trade association expenses.
Carpentry and repair tools.
Heaters.
Spare parts (nozzles, fittings, etc. . . .)
Mowers.
Advertising and promotional materials.
Propagation systems and rooting hormones.
Packing materials and burlap.
Storage buildings (chemicals, equipment, media, supplies, etc. . . .)
Office space and furnishings.
Utilities and insurance.
Parking areas and roads


Container nurseries require much equipment.

However, proper selection can sometimes help solve the problem, "How are you going to keep them down on the farm . . .?

Variable Costs For A 16-Acre Container Nursery, Zones 7 And 8, 1986

	Andora juniper			Kurume azalea			Japanese holly			Crapemyrtle			Red Maple		
Item Amount	**Amount**	**Cost**	**%***	**Amount**	**Cost**	**%***	**Amount**	**Cost**	**%***	**Amount**	**Cost**	**%***	**Amount**	**Cost**	**%***
Propagation subtotal	65,340	3,877	6	108,900	10,651	8	130,680	11,109	9	87,120	5,181	6			
Machinery and equipment subtotal	65,340	433.00	1	108,900	724	1	130,680	839	1	87,120	578				
Container production chemicals, media, pots, etc. subtotal	65,340	18,891	30	108,900	40,165	31	130,680	50,645	39	87,120	29,264	36	8,712	22,237	36
Machinery and equipment subtotal	65,340	3,428	5	108,900	5,514	4	130,680	6,359	5	87,120	4,695	6	8 ,712	3,808	6
Labor	1,906 hr.	9,822	16	3,320 hr.	17,161	13	3,812 hr.	19,644	15	2,54 r.	13,163	16	1,72 r.	6,040	10
Interest on operating capital @ 11.5%, 6 mo.	65,340	2,096	3	108,900	3,613	3	130,680	4,407	3	87,120	2,710	3	8,712	1,846	3
Total variable cost	65,340	38,547	62	108,900	66,453	51	130,680	81,055	63	87,120	49,833	61	8,712	33,931	55
Average variable cost per plant	65,340	.66		108,900	.68		130,680	.65		87,120	.66		8,712	3.90	
Fixed cost per crop	65,340	24,085	38	108,900	63,081	49	130,680	48,171	37	87,120	32,114	39	8,712	27,526	45
Average fixed cost per plant	65,340	.41		108,900	.64		130,680	.39		87,120	.42		8,712	3.51	
Total fixed plus variable cost	65,340	62,632		108,900	129,534		13,680	129,226		87,120	81,947		8,712	61,457	
Total cost per plant	65,340	1.07		108,900	1.32		130,680	1.04		87,120	1.08		8,712	7.41	

* Percentage of total cost.

Variable Costs For A 32-Acre Container Nursery, Zones 7 And 8, 1986

	Andora juniper			Kurume azalea			Japanese holly			Crapemyrtle			Red Maple		
Item Amount	**Amount**	**Cost**	**%***	**Amount**	**Cost**	**%***	**Amount**	**Cost**	**%***	**Amount**	**Cost**	**%***	**Amount**	**Cost**	**%***
Propagation subtotal	130,6805	7,753	7	217,800	21,303	10	261,360	22,219	10	174,240	10,362	7			
Machinery and equipment subtotal	130,680	892	1	217,800	1,492	1	261,360	1,729	1	174,240	1,191	1			
Container production chemicals, media, pots, etc. subtotal	130,680	37,781	35	217,800	57,577	27	261,360	77,391	34	174,240	47,011	33	17,424	44,476	46
Machinery and equipment subtotal	130,600	6,496	6	217,800	10,500	5	261,360	2,034	1	174,240	8,902	6	17,424	4,085	9
Labor	3,812 hr.	19,644	18	6,660 hr.	34,322	16	7,624 hr.	39,288	17	5,109 hr.	26,327	19	1,595 hr.	8,220	
Interest on operating capital @ 11.5%, 6 months	130,6005	4,173	4	217,800	7,199	3	261,360	8,778	4	174,240	5,393	4	17,424	3,265	3
Total variable cost	130,600	76,741	71	217,800	132,393	62	261,360	161,440	72	174,240	99,186	70	17,424	60,046	62
Average variable cost per plant	130,600	.65		217,800	.68		261,360	.65		174,240	.65		17,424	3.45	
Fixed cost per crop	130,600	31,625	29	217,800	82,828	38	261,360	63,251	28	174,240	42,167	30	17,424	36,143	38
Average fixed cost per plant	130,600	.27		217,800	.42		261,360)	.25		174,240	.28		17,424	2.30	
Total fixed plus variable cost	130,680	108,366		217,800	215,221		261,360	224,690		174,240	141,353		17,424	96,189	
Total cost per plant	130,600	.92		217,800	1.10		261,360	.90		174,240	.93		17,424	5.75	

*Percent of total cost.

What Plants To Grow?

A difficult question often asked by potential nursery producers is, "What plants should I grow?" A more appropriate question is, "What plants can I sell and to whom do I sell them?" There are thousands of plants from which to choose. Not only do you have to choose which plants to grow, but you must also be able to predict from 3 to 10 years in advance which species or cultivars and which sizes of plants are going to be in demand. A good marketing program can help create a demand for a particular plant, but change comes very slowly in the nursery and landscape industry.

A potential nursery producer has two options in selecting a crop.

1. One general rule often proposed is that a nursery producer should grow about 70 percent of the tried-and-true, staple nursery plants such as maples, dogwoods, pin oaks, junipers, Japanese hollies, and dwarf nandinas, and 30 percent of the plants that some experts project to have a bright future such as Natchez crapemyrtle, leyland cypress, ornamental grasses, sourwood, hostas, and Japanese maples.

With the increase in the number of large nurseries producing large quantities of container plants, this option is becoming less feasible. However, it is an option for the small grower servicing a local market. Having a nursery in close proximity to the job reduces transportation cost and is convenient for small pickup items.

2. The other option is to select a plant or a group of plants and specialize. This option would include some of the plants previously mentioned or groups of plants, such as dwarf conifers, rhododendrons, native plants, perennials, and water plants. Be careful not to begin with so many plant species that you can't produce the quantities needed to supply some of the larger or mid-sized jobs. You can ruin your operation in a hurry with a reputation of producing quality plants but never having enough to fill an order!

One question that should be asked to reduce the number of choices is, "Who are the target customers or to whom will the plants be sold?"

In general, plants being sold to retail garden centers will be composed of more common varieties such as red azaleas, white dogwoods, or crapemyrtles, and fewer named cultivars such as Springtime or Cherokee Princess dogwood. If the target audience is the landscape trade, more emphasis should be placed on selecting quality, named cultivars such as disease-resistant crabapples and selected holly varieties (Sparkleberry, China Girl, Blue Princess, and their male counterparts). Most landscape professionals are more aware of the desirable traits of the selected cultivars than the home gardener. Selecting these plants will assure the desired effect anticipated in a landscape plan.

A producer can decide to specialize in large trees for the landscape or in liners to sell to other producers.

The ordinary home gardener's knowledge is generally limited to selecting pink or white dogwoods or pink, white, or purple azaleas. The layperson often has not been exposed to or is not interested in the benefits of selected cultivars.

The crucial question of "What to grow?" is not one to be taken lightly. Much research and probing should be initiated so that informed decisions can be made.

A good way to get a feel for which plants are needed is to contact as many of your potential customers as possible and ask their opinions on which plants are in constant demand, short supply, or have potential for the landscape industry. Don't depend on the individual who says "I'll buy all the *Plantamus superii* you can grow!" Three years later, *Plantamus superii* has become *Plantamus dogii* and you are left with ditch filler.

Another method for getting a feel for the plants that are in demand is to notice the most commonly used plant materials in new landscapes. It is important to read as many of the trade magazines and home horticulture magazines as possible to gain and maintain a feel for trends in the industry. A plant featured in a major home garden or horticulture magazine can skyrocket to stardom overnight. Take advantage of the free promotion.

Marketing is an extremely important part of the nursery business and should be given status and attention equal to that of production. Plant selection is part of marketing. Once the commitment has been made to start a nursery business, marketing begins.

Before the first cutting is stuck or the first liner is potted or planted in the field, the nursery manager should be attending nursery meetings, trade shows, and retail and landscape contractor meetings. Make your plans known to potential customers so that they will be ready to buy when the plants are ready for sale. To stay competitive, leaving the nursery for industry meetings is a necessity; you must set your goals and budget for personal contacts with the industry.

As a small grower, you will find that larger nurseries have an advantage of lower cost per container. Larger nurseries have the advantage of the economy of scale. This means that the larger nursery can produce plants cheaper by spreading overhead and fixed costs over a larger number of plants, thus reducing the cost per salable plant.

The three major areas in which nursery producers compete are production, shipping, and quality. It is very difficult to compete with larger nurseries on production costs. Therefore, competition must come from producing higher-quality plants or reducing shipping costs.

You can reduce shipping costs by servicing a local area and providing convenience. Another area in which smaller nurseries can compete is by doing something different in marketing or in production. Crop selection is an important factor in competing effectively.

A limitation of larger nurseries is that it is more difficult for them to make rapid changes. Smaller nurseries can fill a niche by producing specialty nursery crops. These are crops that are not in large enough demand to warrant high-volume production or plants that require special skills and handling. Some examples of these crops include dwarf conifers, wildflowers, ferns, native plants, or other crops that may require special seed handling, shipping requirements, pruning, production, or propagation skills. The production of selected varieties of collector plants and new introductions of hollies, Japanese maples, rhododendrons, azaleas, magnolias, and other special plant groups offer opportunities for entry into the nursery business.

Other specialties that require additional skills plus high labor input include the production of bonsai plants for retail nursery and hobbyists, espaliered plant materials, and topiary plants. Remember that dealing in specialty plants requires a larger market area to reach potential buyers. This market is often accessed by mail-order catalogs or classified ads in garden publications.

Another method or avenue for competing with the larger nursery producers is to select a plant and grow it for a specific target audience or package the plant in a unique way and market it as a holiday plant. Some plants may be marketed as science project kits for children to learn some basic principles of botany. Another example is the nursery grower who marketed single-stemmed rooted roses in a special package to be sold for Mother's Day. School children could be targeted for reforestation projects with genetically superior clones of hardwood and coniferous trees.

Pattern gardens could be developed using the various weed barrier materials. Nurseries could also specialize in growing vines or groundcovers. In addition they could specialize in growing large-container specimen plants for patios and businesses. There has been a rapid departure from the old practice of selling bare root trees as packaged or processed balled plants. The market is demanding container trees. Developing a mail-order business of rare and unusual plants is also a possibility for a specialized nursery.

> The nursery industry is very diverse. It is a business, and like any other business the probability of success depends on imagination, determination, planning, and good management of the five major resources: money, labor, materials, space, and time. Because nursery plants are agricultural crops, risk is involved from uncontrollable factors such as the weather, insects, and diseases. Just as in other small businesses, the nursery producer must stress quality, service, and "the personal touch" to gain and maintain a place in the market.

A number of plant materials currently are in demand—some hopefuls and some long shots. Obviously, the greater the long shot, the greater the risk, and the more attention required in the marketing area. Minimize your risk through diligent study of the market and proper planning.

Nature has provided us with more choices of beautiful plants than anyone can hope to learn. No one can grow them all. Select a group of plants, study them thoroughly, and grow quality plants backed with reliable service. **Start small!** New nurseries can often grow plants much faster than they can sell them. Find your niche—there is plenty of room for the right people.

Comparison Of Field And Container Operations

Each of the many decisions that a nursery producer must make leads to a different set of options. This is why no two nurseries are just alike. One of the first major decisions to be made is, "Should I produce the plants in the field or in containers?" The following information lists some of the pros and cons of both systems.

- A container nursery requires less land. Approximately 5 to 10 acres is the size of a small container operation. About one-third to one-half of the land will be allocated to roads, buildings, storage areas, etc. About 0.8 square foot is required for each 1-gallon container.
- A small field nursery is considered to be about 50 to 70 acres.
- A field nursery's labor demands vary with the season. A family operation with both husband and wife actively involved in the business of about 70 acres requires about 3 to 4 additional workers during peak times of digging, planting, pruning.
- A container nursery requires the assistance of at least one employee per 1 acre of containerized plants.
- Container nurseries require intensive cultivation of a large number of plants but also offer greater returns per acre than field nurseries. In general, the return on an investment in a container operation can be realized in one-half to one-third the time of a field nursery. In a container operation, you can hope to see a return of money invested in 4 or 5 years.
- Costs for a container production operation are much higher than for field production. Startup costs are more expensive. Field production costs are heavy during harvesting of the crop.
- The intensity of management for a container nursery is more critical. Because of the reserve and buffering capacity of the soil, field-grown plants can tolerate human error much more than container grown plants.
- A container nursery requires greater year-round attention and labor than field nurseries. It is hard to be a part-time container nursery producer. You cannot leave a container nursery on vacation without having a competent manager to fill in during your absence.
- Most plants grown in the field can be grown in containers and vice versa. However, some of the more difficult to transplant plants or those plants that do not produce a dense fibrous root system to hold a good ball may be more successfully produced in a container.
- Producing some plants in the field is more economically advantageous than in a container. Larger specimen trees and shrubs are an example. However, there is a rapidly increasing demand and a niche for producing these types of plants in containers in order to have year-round availability for planting. These plants command a higher price but require more time and money to produce.
- A container-produced plant affords the option to the grower to shift a plant to a larger container for sale the next season if it is not sold during the current season. In the field, at some time plants reach maximum density and must be dug and sold or sacrificed to make room for growth of remaining plants. In container production there is often a time when it becomes obvious that the plant will not sell. No matter how long you wait, the decision finally must be made to throw the plant away.
- Container areas are much more expensive to construct and maintain than field areas.

Container nurseries require more labor than field nurseries. Sanitation is very important for the health of the plants and for marketability.

A nursery requires large quantities of high quality water.

- The most important requirement for any container nursery is the availability of large quantities of high-quality water. At least 20,000 to 40,000 gallons are required per acre each day.
- The value of field nursery stock is rising to the point where it is economically feasible and sometimes mandatory to provide irrigation for field nursery stock. This is especially true for the production of field-grown liners or high-value crops like dogwood cultivars, selected maples, or other expensive lines.
- Field production requires less fertilizer use and application. Most Alabama soils have a natural supply of many of the plants' required nutritional elements. Container media supply very few, if any, of the required elements for plant growth. Nutrients have to be added to the mix and monitored throughout the season.
- Weed control is a major consideration in both field- and container-production schedules. Rates are more critical for herbicide application in containers than they are in the field because of the more open container media and lower cation exchange capacities. However, newly planted nursery fields with high weed pressure sometimes require 2 to 3 years of good weed control practices to gain good control.
- Disease and insect control requires closer attention in the container nursery than in the field nursery. The high density and heavy water demands of plants in a container nursery reduces air movement and creates an environment more conducive to development and spread of diseases.
- Container plants are more susceptible to physiological stresses such as heat and cold than field-produced nursery stock. Roots in containers are more sensitive to these stresses than the tops. Soil provides an excellent buffer to these extremes in a field nursery.

Many retail nurseries will no longer purchase packaged trees or processed balls because of poor root systems, limited planting time, and survivability.

- Plants requiring shade for optimum growth are usually produced in containers under artificial shade or under the canopy of trees in the nursery. The requirements of shade can sometimes be met through more frequent watering of the containers. However, this practice can also be detrimental.

Natural shade can be used for container production, but excessive water can kill these trees.

- Some form of winter protection is required for container-grown plants in Alabama. The cost of overwintering increases from South to North Alabama. Only a few plants in North Alabama will tolerate the extreme cold temperatures in conjunction with the sporadic warm spells of Alabama's winters.
- The major advantage to container-grown plants is the ease of harvesting and handling of these plants as opposed to the digging and storing of bare root or balled and burlapped plants from the field.
- Containers can be harvested, shipped, and planted during any time of the year, whereas field-grown nursery stock is harvested when field moisture is adequate and the plants are dormant.
- Bare root plants and container plants can easily be stacked and shipped whereas balled and burlapped trees are very heavy and costly to ship as well as being very difficult to handle.
- Container and field operations each have their own specific requirements for equipment. Container nurseries require specialized equipment for media mixing and handling as well as more transportation equipment. Additional people are needed to manage the plants.
- A field nursery requires more sophisticated harvesting equipment or a knowledgeable, hard-working labor pool. Labor is becoming more and more difficult to find.

Quality plants can be grown by either method. The production method selected depends on the market, plants selected, site conditions, amount of land available, and irrigation capacity. The financial situation, personal expertise, and preferences of the owner are also contributing factors.

Goals For The Design Of A Container Nursery

Make a plan for your nursery before you begin to pot your liners! Container nurseries are labor intensive and labor is the major expense in container production. The main concern in planning is to reduce the labor required in container handling. No one plan is best for all nurseries. A plan that offers a centralized business, shipping, and propagation area with movement of plants radiating out to perimeter growing areas has worked well in many nurseries but may need to be adapted to fit your location.

Your site may offer some natural resources such as streams, ponds, wind breaks, road frontage space, shade, or other benefits that make it necessary to change the plan to take advantage of these features.

Make plans for future expansion. A common mistake made by new nursery producers is to underestimate the space required for transplanting plants coming from the propagation benches to larger containers. Adequate space is also underestimated for growth and expansion of the nursery. Plan to succeed. Expect to grow. Make several alternative or contingency plans. Test the flow of people and materials by walking through the area to see if the design works. Lots of money can be saved by using an eraser in the planning stage instead of using a bulldozer in the mistake stage.

Check List For Nursery Site Selection

Proper site selection is extremely important and can make the difference in the success or failure of a business—and often does. A check list follows that outlines some of the most important factors to consider when selecting a container nursery site. It is impossible to meet all the requirements, but the closer you come, the more problems you can avoid in the future.

☐ The most important consideration in a container nursery is the availability of large quantities of high-quality water.

- About ½ to 2 inches of water per acre is required for irrigation of container plants. This is equivalent to approximately 12,000 to 50,000 gallons of water per day per acre. Approximately 1 pint of water is required for a 1-gallon container.
- About 5 to 10 acre-feet or 60 to 120 acre-inches of water is required per production season.
- Nursery containers need approximately 100 waterings per year.
- Water quality should be tested before starting the nursery (see Water Quality, p. 29).

☐ Before selecting a site you must select the plants you intend to grow and be sure they are adapted to the particular site.

☐ Determine the best method for producing the plants (field or container).

☐ Are there enough suppliers and employees close by to meet your needs?

☐ Do you know the government regulations on providing a safe work environment? Contact the U.S. Labor Department and the Alabama Plant Industries Division to get information on Right To Know Laws and other important regulations that you must follow.

☐ What is the slope of the land? A 1 to 2 percent slope is adequate. The slope should be no greater than 5 percent. Grading is expensive!

☐ Heavy clay, poorly drained soils will require extra grading and planning to move away excess water.

☐ Low areas may create frost pockets for settling of cold air.

Selecting a site with windbreaks or establishing windbreaks early can save much labor in standing plants up.

☐ What direction are the prevailing winds and where will screens need to be grown?

☐ Wind tunnels or areas with high winds necessitate building or growing windbreaks.

☐ Windy hilltops make irrigation design and pesticide spray difficult. However, it is advantageous to have some air movement to reduce insect and disease problems.

☐ Large rock outcroppings may limit movement through the nursery or development of production areas.

☐ Are natural shade areas available for the production of shade plants? These usually cannot be considered permanent production areas because of the heavy water requirements of container plants. Satisfying the water needs of the container crop causes excess watering of the pines or other shade trees.

Nursery beds should be crowned, compacted, applied with herbicide, and covered in plastic, ground cloth, or gravel.

☐ Aerial photographs and topographic maps can be very beneficial in the planning process.

☐ Enlist the aid of the Soil Conservation Service to test for drainage and planning for water flow off the nursery.

☐ What are the taxes on the land of the potential nursery site?

☐ Investigate zoning restrictions or possible plans for surrounding land. Build permanent structures and greenhouses far enough from the road to allow for widening of the road and to prevent relocation expenses and losses of valuable time and labor. These things happen; plan for them!

☐ Are any heavy industrial areas nearby that may adversely contribute air or water pollutants to the nursery?

☐ Check places where water may wash onto your property from adjoining areas. Could the water contain harmful pesticide residues or nematodes or disease?

☐ Two to three million gallons of water are used per acre of container production per year. Eighty to ninety percent of this water is lost in run-off. Provisions must be made to direct this water safely off the property or to holding ponds. Although not regulated yet, it is highly probable that catching all runoff will be mandatory in the future. Including this feature in your planning process is a good idea.

Provisions must be made to direct water off the property.

☐ Is there access to major roads, truck transportation, and utilities?

☐ Is there access to 3-phase electricity at a reasonable cost? Backup water reserves and electricity need to be planned for in the beginning stages.

☐ Marketing begins on day one. The nursery needs to be convenient to both buyers and shippers.

☐ Proximity to other nurseries can be an advantage. Through cooperative buying, marketing, shipping, and sharing of technology and equipment, costs can be reduced. A common practice among nurseries located in the same area is to pool plants to make up shortfalls in numbers to fill orders. Information can also be shared easier. Some area nurseries form cooperative agreements for exhibiting at trade shows.

Planning The Site

As with any other endeavor, planning ahead saves costly mistakes. Take some time and follow the guidelines below when planning your nursery.

- Use topographic and aerial maps to lay out container beds, propagation areas, irrigation lines, and storage, office, and work buildings and a sales office.
- Plan for irrigation ponds, collection ponds, media mixing areas, shipping areas, roads, and customer parking.
- Plan the nursery to provide the least amount of movement of people and plants.
- The container area should be laid out in a concentric pattern with production radiating out from a central area to the final production beds on the outer perimeter. Linear layouts are also used with production progressing out from a central office and propagation areas to container production areas and shipping. Areas for propagation, container production, shade, and overwintering structures should be planned first, followed by shipping and office areas.

Some nurseries space their container beds 8 to 10 feet wide with 2-foot aisles for walking and pesticide application equipment.

- Ideally, container media should be stored at the highest point on the nursery site on a paved slab with all weeds surrounding the area removed. Black plastic can also be used for media storage with the goal of pouring a concrete slab when funds are available.
- Irrigation ponds should be located above the production areas, if possible, to save on pumping costs.
- Container beds should be no more than 50 feet wide and can range up to 600 feet long. Beds may be wider if movement of containers is automated such as by a conveyor system. Carrying containers more than 25 feet can be very tiring and inefficient for workers. Take the size of your equipment into consideration when laying out your beds. Some nurseries make beds to allow container blocks 8 feet wide with 2-foot walk ways to accommodate automated pruning, spraying, or herbicide application.

Landscape your office. Take pride in your profession, and create a good first impression.

- A well-landscaped sales and office area should be included in the plan to show pride in the profession. Exhibiting mature plants for potential customers in an attractive display can increase sales. Creating small container areas to display samples of all your available plants reduces time traveling all over the nursery for customers to see plants and can serve as a sales area for small purchases.
- A stock block area for propagation that can double as an area for exhibiting available nursery stock is a possible alternative.
- Sometimes it is better to tear down or move buildings rather than force them into an unworkable design.
- Only 60 to 70 percent of the space is available for production areas. The remaining areas are used up in roads, storage, office, and support areas.
- Roads within the nursery need to be 15 to 20 feet wide. Roads in the shipping areas need to be 25 to 35 feet wide to accommodate large trucks, with adequate room for turn around. Allow for wide turns if large trucks will drive through production areas.
- Theft is a problem in the nursery. Both people and deer find your plants very appealing. Consider electric fences for the deer.
- Labor is the most expensive item in the nursery. Do not compromise ease of labor movement.

Order Of Development

It is important to get the production areas established first so that this phase of the operation can be implemented.

1. Grade and prepare land for container-growing areas and drainage systems.*
2. Plan water source and irrigation layout for production areas.
3. Designate temporary or permanent storage areas for media and supplies.
4. Develop mixing and potting area.
5. Create passable roads.
6. Construct entrance area and parking area. First impressions are important. Hire a landscape designer if this is not one of your talents.
7. Build office (temporary or permanent structure).
8. Develop the loading area.
9. Plant windbreaks and establish propagation stock blocks.

After everything is set up for initial production and plants and supplies have been ordered, additional container beds, water sources, buildings for storage, more permanent buildings for employees, and an office can be established. The entrance area can be landscaped, more parking created, and preparation for shade exhibit areas and overwintering structures can be planned and constructed.

These actions can be followed by backup water sources, installation of propagation areas, building more permanent roads and drainage systems, implementing plans for recycling water, and installing laboratories for experimentation and testing in the nursery. A thorough financial plan must be made prior to construction to see if capital is available to make the nursery a success.

Break For Crop Scheduling

As most of us know, a little time spent planning can often save a great deal of time, money, and headaches. This is especially true in container production.

A common occurrence among new nursery producers is that they underestimate the space and material requirements to handle plants as they move through the various production stages.

Double cropping can sometimes be used to maximize space and take advantage of shade from tall crops.

* Note: It is best to concentrate on one aspect of production when first getting into the business. If possible, buy liners for the first year or two of production until this area is running smooth and then establish propagation areas. However, you can start a liner nursery and concentrate on that aspect of the business and sell liners rather than finished crops.

When rooted cuttings come from the propagation bench, they seem to explode to a space of 20 to 40 times that required during the propagation phase. The situation becomes unmanageable. Adequate space, fertilizers, media, herbicides, irrigation, labor, etc., have not been coordinated. The manager reacts to one crisis after another and quality and profits suffer. At this point, the business begins to lose some of the appeal that initially enticed you. Look at the following example of how a little math can help you determine and prepare for your space requirements.

Example. Assume you are producing a crop of 1,000 *Ilex* x Nellie R. Stevens holly. A number of production schemes can be used, but for simplicity and space requirements of this article, assume that the plants will all be sold in 3-gallon containers.

In October cuttings are stuck in flats at a 1-inch x 3-inch spacing. Rooted cuttings are ready to be shifted to 1-gallon containers in April. Assume that 80 percent of the cuttings stuck will be suitable for repotting. The hollies grow for 1 year and are shifted the following April to 3-gallon containers. Ninety percent of the plants in 1-gallon containers survived or are acceptable for repotting in 3-gallon containers. These plants grow until they are ready for sale in the fall. Ninety percent of these plants are also assumed suitable for sale. How much space will be required to produce a continuous crop of 1,000 hollies? The job becomes easier if you begin by calculating the space requirement for one salable 3-gallon container. Then, work backwards to the space needed for cuttings and the number of cuttings required to produce the one salable plant. Follow the steps of the crop worksheet below.

Crop Worksheet for 1,000 Hollies in 3-Gallon Containers

	Cuttings (80%)	1 Gallon (90%)	3 Gallon (90%)	Saleable
Plant Ratio* Saleable Plants divided by % Survival	1.54	1.23	1.11	1.00
Spacing & Area/Plant (square inches)	1×3 inches 3.00	12×12 inches 144.00	23×23 inches 529.00	
Area for 1 Plant step 1 × 1,000	4.62 +	177.12 +	587.19 (square inches) 768.93 =	Total Area
No. Plants required per phase Step 1 × 1,000	1,540.00 (cuttings)	1,230.00 (1 gal.)	1,110.00 (3 gal.)	1,000.00 Saleable
Area for Total Plants (square inches) Step 2 × 4 divided by (144 square inches = 1 square foot)	4.62 (32.10 square feet)	177,120.00 (1,230.00 square feet)	587,190.00 (4,077.70 square feet)	Area 769,930.00 (5,346.70 square feet)

*Remember to work backwards (1.00/0.90 = 1.11)

This is certainly a long way from computing all the space and materials required, but it illustrates a starting point. Within 10 to 15 minutes you can calculate this much and have some valuable information for planning. By knowing the space required to produce one 3-gallon holly, you can easily project to 10,000 if you want to do some "what if?" planning. You know the propagation space and the space required for each container size. (For computer buffs, this type of math lends itself well to computer spreadsheets.) Once this initial planning is done, it can easily be referred to and adjusted in the future for other crops and production schemes.

Where to go from here? You can continue with the space utilization planning by determining the size of your propagation benches and growing areas and allocating the space needed or preparing additional beds to meet the requirements. You can also calculate the media, fertilizer, and herbicide requirements for each container size and project the amount of materials that will need to be ordered for the entire crop.

Draw diagrams of your production and propagation areas and make copies of your drawings. Plan your crop schedule on paper and look at the flow of work. As most nursery workers find out in a hurry, most of the work in container production is moving pots from one area of the nursery to another or pushing them together for overwintering. Use this planning tool to make your nursery more efficient.

It is not so important which method you use or the order in which you make your calculations. The main point is to take time to do a little planning and gain control of your business as much as possible. You may find that planning helps you recover the joy and enthusiasm that you had as you envisioned beginning the business. Planning is not a waste of time, it saves time! Make it a priority in your business.

Selecting Container Media

Uniformity is a major goal in the production of nursery crops. A uniform, high-quality crop must have a uniform container medium. A common recommendation for a good container medium is a 3:1:1 or a 4:1:1 pine bark:peat:sand blend. However, there is no magic number in the 3:1:1 or 4:1:1 mix. These are general recommendations that have proven successful in the past. The grower must analyze the container medium and adapt the cultural practices to suit that particular medium.

The container medium provides anchorage for the plant roots and serves as a reservoir for the required nutrients, oxygen, and water necessary to sustain plant life. Any medium that provides the necessary physical and chemical properties in proper balance—and is non-toxic to the plant—is acceptable. There is no perfect medium. Because of the wide variety of plant materials grown in different-sized containers, one or two good media are the best you can do.

Poor drainage or media that stay too wet in containers is probably one of the biggest problems in containers. This can be caused by overwatering or a container mix that is too tight (lack of adequate air space). Black root rot, phytophthora, pythium, and other diseases are much more prevalent in high-moisture environments. Thus, you need a well-aerated container mix. The propagation bed can also have a problem of being too wet. Plants in an aerated, open medium in the propagation bed will have much better roots than those in a tight mix.

Container media should be stored on a concrete pad and the area surrounding the pad should be kept free of weeds.

Many components are used in container mixes. Peat moss has been used in the past, but for some uses, it has become too expensive. Pine bark is currently the medium of choice for Alabama because it is the one that is most readily available and its price is acceptable to the industry. Pine bark is also the medium that is backed by the most research. However, there are many other mixes that people are either trying, researching, or using on a limited basis.

Composted hardwood bark is a medium that is currently being used successfully as an amendment to pine bark at a rate of no greater than 50 percent. Other medium amendments that have been investigated include peanut hulls, cotton seed trash, carpet remnants, rice hulls, chicken litter, and sewage sludge.

Rice hulls have proven to be advantageous in the Mobile area where costs are competitive. Rice hulls can be used alone but it is more commonly used as an amendment to pine bark.

If bark prices begin to rise, growers may need to change to some other medium. Pine bark ranges from $6 to $12 per cubic yard. We are fortunate to have a large source of bark in Alabama. In other states, growers pay up to $30 for the same product. This is part of our competitive edge.

You should be careful if selecting anything other than pine bark, except for experimental purposes. Be especially careful of sawdust, uncomposted hardwood bark, and some of the other products that are often suggested to "save money." The actual cost of the container mix is low compared to the total production cost of the plant. Plants in 1-, 2-, and 3-gallon containers sell for about $2 to $3, $4 to $5, and $6 to $7 wholesale, respectively. A container mix usually costs about 5 cents per pot for a 1-gallon container or 15 cents per pot for a 3-gallon container. Saving 1 cent a pot by substituting free sawdust in a medium can cause a much greater loss in value of the plant, because of reduced growth as a result of the sawdust.

Many producers mistakenly feel that if they have pine bark in the container, there is no cause for testing or concern. All pine bark is not equal. If you go to seven sources for pine bark, you will have seven different mixes. Different sources have different particle size distributions, which results in varying physical properties in a container medium. If you understand these properties, you can make necessary adjustments.

Five factors influence the availability of water and air in a container medium:

(1) The particle size distribution or the relative range of sizes of bark in the medium.

(2) The bulk density or the degree to which the mass or weight of the bark particles are compressed together.

(3) The unsaturated hydraulic conductivity, which is the lateral movement of the water in the container.

(4) The pore space or the total volume of open space in the container that is available to store the water and air.

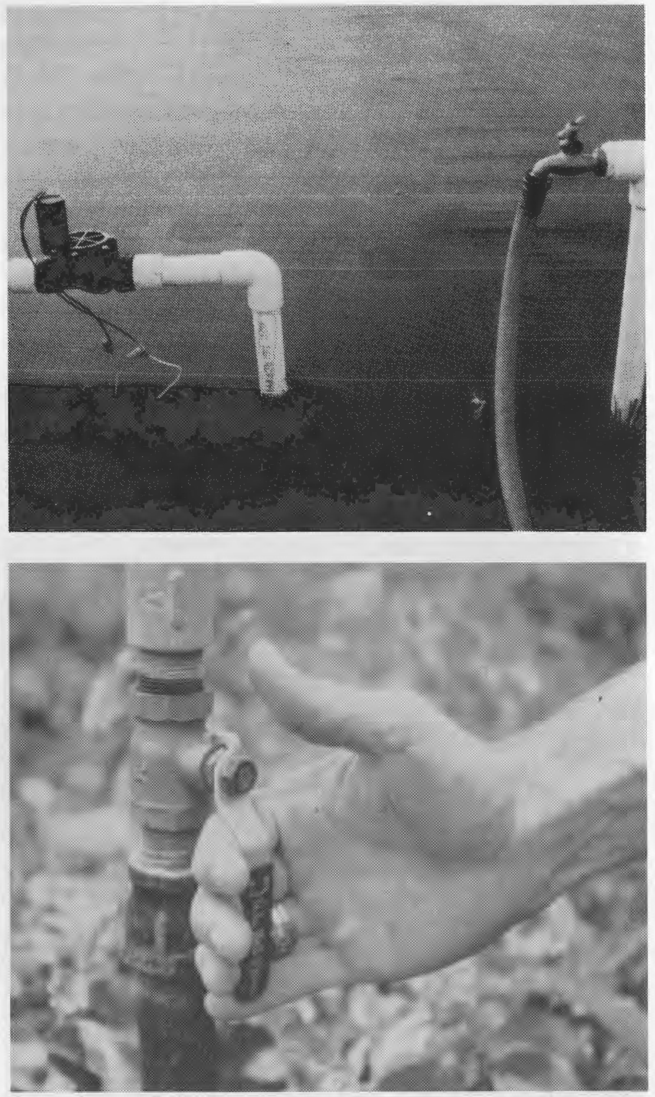
(5) The hydrophobic nature of the bark substrates.

Particle size distribution and how tightly the bark particles are compressed join together to form the pore size distribution. When water is poured through bark, some water passes down through the pores and out the bottom, some is taken up in the interior of the bark particle, and some is attracted to the outer edge of the bark and held there. Some water is also caught in the small pores and held against gravity. A good balance of water and air is needed in the pore spaces. The total pore space in a container mix is somewhere between 50 and 70 percent. Of that total, 20 to 30 percent should be air space and the remaining 30 to 40 percent should be water. Some of this water is available to the plant. The attraction of the bark particles for the water is stronger than the gravitational pull on the water so it remains in the pore. The larger the particles in a container mix, the larger the pores will be and the more water that will drain through. This results in more air space. Conversely, the smaller the particles, the smaller the pores will be. More water and less air space will be in the container.

A good balance between air space and water-holding capacity is needed for optimum growth. The width of the container has no bearing on drainage. At the bottom of each container there is an area of saturation. The height or thickness of this area of saturation will increase with the smaller particle size distribution.

Roots need oxygen to survive and grow. Poorly drained media is an invitation to disease and disaster.

The height of the container influences the wetness and dryness of a container mix. From the saturated layer at the bottom of a container, the medium gets progressively dryer as you move up to the top of the container. Therefore, the fuller the container is, the dryer the medium at the top will be. A shorter container such as a propagation bench would make it more difficult to use the same container mix that you would use in a 3-gallon container. Containers are designed so that 1-, 2-, or 3-gallon containers do not differ much in height. The difference in size comes from the width of the container. There is not enough difference in height to warrant changing a container medium when shifting from a 1- to a 3-gallon container. Larger containers are not as physically restricting to the roots and offer an increased volume of water, nutrients, and air available to the plant. These factors usually result in increased growth when potting directly into a larger container.


Open, porous container media dry fast. Be flexible and provide convenient faucets for spot watering and shut-off valves to get into blocks during irrigation.

A problem rarely seen today is the practice of putting rocks or larger bark particles in the bottom of a container to increase drainage. This practice results in raising the saturated layer in the bottom of the container to a higher level and puts the plant in a wetter environment than it was originally. Water is held in the smaller pores and will not run into the larger pore spaces. It is held against gravity until enough water accumulates to push it out.

Some research indicates that it is possible to use sawdust or uncomposted hardwood bark and get by for short periods of time. However, by using this material, there is a risk of the bark or the sawdust further decomposing. As it decomposes the particle size distribution gets smaller and air space is lost. It is not economically sound or worth the risk to cut corners in this manner. There is also the problem of competition by microorganisms with the plant for available nitrogen.

Another component that is often used in a container mix is sand. Sand is primarily used for keeping containers upright in the field. It is used for weight. Sand has some water-holding capacity and some nutrient-holding capacity. However, the overall effect of using sand in a container mix can be detrimental. By understanding the problem, you can compensate for the detrimental effects of the sand. When sand is placed in a container mix, the sand particles fill in the large pores and reduce the amount of air space. Therefore, you need to have enough air space (about 30 to 40 percent), or available large pores so that when sand is added the air space is not reduced below the target number of 20 to 30 percent. Sand should only be used in a container medium where you are concerned about the plants turning over. With small plants that are grown pot-to-pot or with low-growing plants such as blue rug juniper, it is not necessary to add sand. On the other end of the scale, it is not necessary to add sand to large trees that must be staked in containers anyway. The size of the sand particle that you add is very important. It should be a sharp builder sand. Sharp builder sand means something with a particle size of at least 1/16 to 5/64 inch.

If you have a problem of excessive drainage, what can you do? If your medium tests shows air space greater than 30 percent, you can reduce the particle size distribution and increase the proportion of fine particles by processing your bark through a hammer mill. This reduces the size of the larger particles so that the mix will be tighter and have less air space and more water-holding capacity. Peat moss or a peatmoss substitute can also be added to increase the water-holding capacity. If the problem is too little air space, increase the height of the container. Another option is to amend the medium with perlite, vermiculite, or a bark material that has been screened to a larger size. The medium can also be run through a screen to filter out some of the fine particles and open up some of the large pore spaces.

Once you have found a good medium that produces desired results, be cautious about changing to new and "cheaper" materials. If you are considering changing to another medium, be sure to try it on a small scale first. Test the medium for air space and water holding capacity and send a sample to the soils lab for chemical analysis. Your container medium is an extremely important part of container production. Do not take it for granted.

Measurement Of Medium Air Space And Water Holding Capacity

MATERIALS NEEDED:

- Measuring cup.
- Plastic freezer bag for waterproof liner.
- Crayon or marker.
- Pan to place under the container.
- Suitable objects to place under the pot or the pan to allow for good drainage.
- The container and medium to be tested.
- Water.

PROCEDURE:

1. Measure the volume of the container. Place the plastic bag in the container. Fill the pot with water to the soil line and make a mark at that level. Record the amount of water needed to fill the pot. This figure represents the "total volume of the pot." Dump out the water.

2. Fill the container with the growing medium to the mark or to the same level the water reached in the container.

3. Slowly fill the container with a measured amount of water until the medium is fully saturated. When a thin film of free water appears at the medium surface, stop. Allow the container to sit for 1 hour or longer. Add additional water as needed as the growing medium can absorb a lot. Record the total volume of water added. This volume represents the total pore space (total porosity) for the growing medium in this particular container. Percent porosity is calculated as follows:

$$\text{Percent porosity} = \frac{\text{Ounces of water required to saturate medium}}{\text{Total volume of the pot (ounces)}} \times 100$$

You are using only one container medium. Group plants according to type, size, and water requirements.

4. After saturating the medium, suspend the pot over the pan and puncture the freezer bag through the drainage holes. Allow the bag to drain about 30 minutes or until no more water drains from the pot. Do not tilt or tip the pot (this increases the height of the column of medium and more water will drain, giving a false reading).

5. Record the volume of water drained from the container. This volume of drained water is equivalent to the air space in the drained medium. The percentage of air space is calculated by the following formula:

$$\text{Percent air space} = \frac{\text{Ounces of drained water}}{\text{Total volume of the pot (ounces)}} \times 100$$

6. The percentage of water retention or "water-holding capacity" of the medium is the difference between the amount of water required to saturate the medium and the amount drained. Water-holding capacity is calculated as follows:

$$\text{Water-holding capacity} = \text{Percent porosity} - \text{Percent air space}$$

The drainable pore space should be 20 to 30 percent for growing most nursery crops. In general, recently mixed media with less than 20 percent drainable pore space are unsuitable for most container plants. More than 30 percent drainable pore space represents excessive drainage and limited supply of water.

Nutrition In Containers

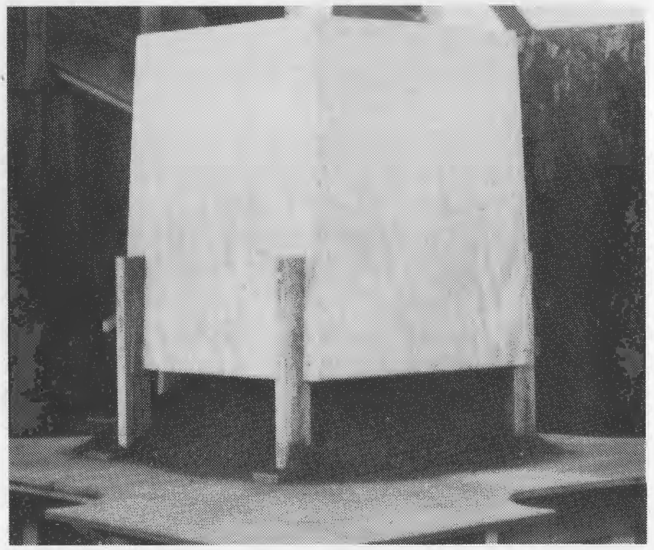
Other than water, fertilization is the most important key to producing a quality plant. Research has been extensive in this area in the past 20 years and advances have been made to help producers set up a personalized fertilization program. Slow-release fertilizers, injectors, and sophisticated monitoring equipment have made this part of the production program simpler and much less labor intensive. However, the producer must understand the basics of nutrition and spend the time and effort to develop a program for the nursery.

It is important to monitor and keep good records of the nutritional status of your container plants. The method is easy and benefits are realized in terms of extra growth, which means dollars.

Many factors affect the uptake and utilization of fertilizer in a container. Some of these include:

- The type of fertilizer used.
- The contribution of nutrients by the medium.
- The pH of the medium.
- The cation exchange capacity of the medium or the ability of the container mix to hold nutrients in reserve for the plant.
- The nutrients supplied by the irrigation water.
- The balance of aeration and moisture in the containers.
- The temperature within the container.
- The size and particular variety of plant being grown.

With all these interrelated factors, it becomes readily apparent that there is no single recommendation that will provide optimum growth for any plant. It is also apparent that producers must develop their own nutritional programs because factors vary greatly among nurseries. The literature is filled with nutritional studies on various ornamental plants. This information is good and helpful in making general recommendations, but the results may not be mirrored in the nursery because of the impossibility of duplicating all the factors mentioned above.



Slow-release fertilizer can be incorporated into the container medium and plant liners brought in for potting at a gravity-fed potting station.

Many acceptable recommendations for fertilizing container plants will get the job done. However, as competition stiffens and nursery producers continue to search for the "competitive edge," it becomes increasingly important to look for ways to produce a higher quality plant in less time while still maintaining a competitive price. Monitoring and recording nutritional levels during the production cycle may be one method of staying one step ahead of competitors. Designing an effective nutritional program will require sampling, testing, and recording on a regular basis. Nursery producers will have to become researchers on the side to develop the best nutritional program under specific growing conditions.

So few nutrients are contributed to the plant by most container media that it is very important that all the required nutrients are provided to sustain plant growth. The following medium amendments are some of the materials used to meet these requirements.

Dolomitic Limestone. For pine bark media, use 6 to 12 pounds per cubic yard of dolomitic limestone. The exact amount should be determined over a period of time by testing the mix for pH and observing the plants. Water, pH, and alkalinity are factors in determining how much to add. (Test your water.)

Even azaleas and rhododendron need some lime, or at least a source of calcium and magnesium. Use 4 to 6 pounds per cubic yard of dolomitic limestone on this kind of plant. Dolomite supplies calcium and magnesium and adjusts pH as well. It is most difficult to adjust pH after the plants are potted. If calcitic limestone is used, some other source of magnesium must be provided. The finer the lime, the faster the pH can be changed to desired levels.

Gypsum. Calcium sulfate (gypsum) provides a source of calcium **without** changing the pH. It is used in hardwood bark mixes at 3 to 4 pounds per cubic yard or in mixes for azaleas, rhododendron, or other acid-loving plants at 2 to 3 pounds per cubic yard. Sulfur is an essential element, but as so little is needed, it is more or less just going along for the ride.

Phosphorus (P). Phosphorus is a major element and an important part of fertilization. One way to provide phosphorus is to add 1 to 2 pounds per cubic yard of 46 percent treble superphosphate (0-46-0). Although phosphorus is a required element, research shows that phosphorus in this form leaches from media. It is not a necessary preplant amendment. However, some producers still like to add it to the medium. Phosphorus is supplied by the slow-release fertilizers.

Trace Elements. It is extremely important to add trace (minor) elements to bark mixes or other mixes not containing soil. Adding trace elements, even to mixes containing soil, is good insurance. Deficiencies of trace elements, namely iron (Fe), copper (cu), zinc (Zn), manganese (Mn), boron (B), and molybdenum (Mo), can cause chlorosis, stunting, growth reductions, or worse. Only small amounts are needed, and **correct** application rates and good mixing are critical. Excessive rates can be toxic to plants and are considered worse than deficiencies because they cannot be corrected by leaching or other means.

Container plants need to be watered immediately after planting to provide moisture and leach excess salts.

Many proprietary formulations of trace elements are available for grower use. Some, like the Fritted Trace Element mixes, are very concentrated and the label may call for as little as ⅛ pound per cubic yard. Others, like STEM, are soluble in water. The easiest way to get good distribution is to spray STEM over the soil pile when batch mixing. Esmigran is absorbed onto clay particles. About 3 to 6 pounds per cubic yard of the material are used, making the mixing job easier. Micromax is another widely used product. It is applied at 1½ pounds per cubic yard. **Always follow recommendations on the label!**

Nitrogen (N) And Potassium (K). If the soil mix is to be used at once (within 10 days), low levels of immediately available N and K may be added to provide quick grow off of newly potted plants. Don't do this with stockpiled mixes. The N and K leaches to the bottom of the pile causing soluble salt problems. Remixing would be necessary. Potassium nitrate at ½ pound per cubic yard provides a quick "shot-in-the-arm" when slow-release fertilizers are mixed in at the same time; up to 3 pounds per cubic yard have been used without slow-release fertilizers.

Wetting Agents. Dry bark is very difficult to wet with just water. Dry bark does not provide the water storage necessary to sustain plant growth. When bark mixes are used, especially fresh pine bark or any bark that has been allowed to dry out, a common recommendation is to add a wetting agent to get the bark to take up water and become hydrated. The wetting agent may be as common as a liquid dish washing detergent or any of the commercial products that are readily available. The amount is not critical and 2 to 4 ounces are commonly used. Application is by spraying a dilute solution over the batch prior to mixing or incorporating a granular product into the mix. (Soluble trace elements could be added in the same solution.) Composted or aged barks should not need wetting agents if they are not dried out.

Moisture Extenders Or Hydrophylic Gels. The use of water-absorbent gels have not consistently proven to be advantageous in a container medium. More research and refinement are needed before recommendations are warranted.

Slow Release Programs

Slow-release fertilizers are the most desirable delivery method for applying fertilizer to containers. With concern for nitrate runoff in our groundwater and increased cost of labor, the slow-release system provides minimal run-off and reduced labor. Liquid feed is an option for supplemental fertilization. It can also be used for drip irrigation systems.

Nitrogen, phosphorus, and potassium can be provided in a slow-release program for initial growth (incorporated or top dressed), or for growing-on. The following materials are examples of these products.

Osmocote/Sierra (Grace/Sierra Horticultural Products, Milpitas, CA 95035): Research has shown that Osmocote is an easy material for the beginning container grower to use and obtain good results. Osmocote is composed of standard inorganic fertilizers encased in special resin capsules, which accounts for its slow release characteristic (osmotic coating). Many formulations and release times are available. Osmocote can be incorporated into the soil mix. It must not be over mixed when sand or other abrasive materials are used. Standardized mixing times are essential in tumbler-type mixers. Osmocote mixes should not be stockpiled for long periods (more than 3 weeks) especially at high temperatures, which accelerates the release rate. Refer to guidelines on the label for rate information for the formulation you are using.

Another way to use Osmocote is to topdress with surface applications of small, measured amounts in each container. In spite of higher labor cost, this is preferable to incorporation in the mix if you do not have equipment to do a good, even job of mixing. Research shows that most plants grow equally well with either method. A disadvantage of topdressing is that rain or sprinkler water may splash the Osmocote out of the container. The topdressing may also spill out during handling or carrying of the containers.

Sierra has produced a product that is very beneficial for topdressing and growing-on or for smaller growers who don't have mixers. Sierra 17-6-10 plus minors is a complete fertilizer that has all the minors, calcium, and magnesium along with the major nutrient package. This gives the grower a complete product to grow an acceptable plant. Sierra 17-6-10 should not be considered as a "miracle, broadcast and forget" product. Monitoring and adjusting for the particular site, plant, and growing conditions are important to get optimum growth. This product is applied at a rate of 7 to 13 pounds per cubic yard.* It is listed as an 8- to 9-month product but the hot summers in Alabama may reduce this longevity to about 5 to 6 months. Formulations are also avaliable for 3 to 4 months and 12 to 14 months.

All the products may require supplemental fertilizer to complete the growing season depending on time of application and temperatures.

Scott's Pro-Grow (Marysville, Ohio 43041): The O. M. Scott Company has developed some fertilizers from methylene-ureas for container nurseries based on slow-release nitrogen. These fertilizers begin to release in 1 to 2 weeks and last 2 to 8 months. Apply these fertilizers two times during the growing season. ProGrow products offer several analyses and release rate options as well as products containing minor elements. Lime is not included in their products. (See label for specific recommendations.)

Mag-Amp is a granular, 7-40-6 material with the nitrogen source from magnesium ammonium-phosphate. Mag-Amp begins to release its nutrients upon coming in contact with moist soil. For container nursery use, the coarse granule has been most effective when incorporated into the soil mix at 15 pounds per cubic yard. Mixes should not be stored longer than 10 to 14 days after mixing. Mag-Amp is not recommended as a topdressing material for fertilizing container plants. This material can supply magnesium if other sources are not readily available. The release rate increases with media moisture and pH.

Agri-Form is fertilizer compressed into tablets or pills of various sizes. Place the 14-4-6 container tablet in the container in early spring just prior to growth and repeat applications every 8 to 10 weeks. Tablets should not be inserted at the same place in the pot as previous applications. One 12-gram tablet per gallon (actual) of container medium is an acceptable rate. Also available are 3 and 6 gram tablets. Complete disintegration of the tablet is essential for best results.

Ureaformaldehyde. Many of the traditional spoon-feed programs have been based on periodic application of dry fertilizers containing ureaform sources of nitrogen such as Sta-Green 12-6-6, Nursery Special, and Perma-Green 13-6-6. The main disadvantage of this type program is the quantity and quality of labor required to apply a spoonful at 4- to 8-week intervals. The first application is generally made in mid March or early April and continued at 4- to 8-week intervals until the end of August. At that time the plants are allowed to harden off before a light application is made to hold foliage color after the first frost.

Ideally, these dry fertilizers should be scattered evenly over the surface. If a spoonful is dumped in one spot, some root injury can develop in the soil column directly underneath. Hand-carried hoppers with precision metering devices, such as Plant's E-Z Feeder, Perfect-A-Feed, or Scott's Drop-Tube Applicator ensure accuracy and improve labor efficiency.

IBDU and Escote (Woodace, Vigoro Industries, Winterhaven, FL 33882). Escote is a new generation of encapsulated fertilizer that releases evenly through its casing and is dependent on temperature and a releasing agent within the casing. Escote is combined with IBDU, which releases by water at a rate dependent on the size of the particle. Vigoro also offers a wide range of formulations with different analyses and release rates. Some products contain minor nutrients without calcium.

Inorganic Mixed Fertilizers

The inorganic mixed fertilizers are common farm fertilizers without slow release properties; all the fertilizer salts are readily soluble. Analyses such as 8-8-8 or 10-10-10 or others can be used on container nursery stock in spoon-feeding programs but **only at low rates.** Generally, more frequent applications at shorter intervals are required for good plant growth. One-half teaspoon per gallon per month is about right. If broadcasting this fertilizer with a whirly-bird spreader, between 1 and 2 pounds per 100 square feet is sufficient. For more even coverage, walk the aisles both ways using a half rate. This helps reduce the "shadow" created by the plant canopy over the container. Apply when leaves are dry. Follow up with a broom to knock the fertilizer off the leaves, then irrigate thoroughly. This is not a preferred program for container production.

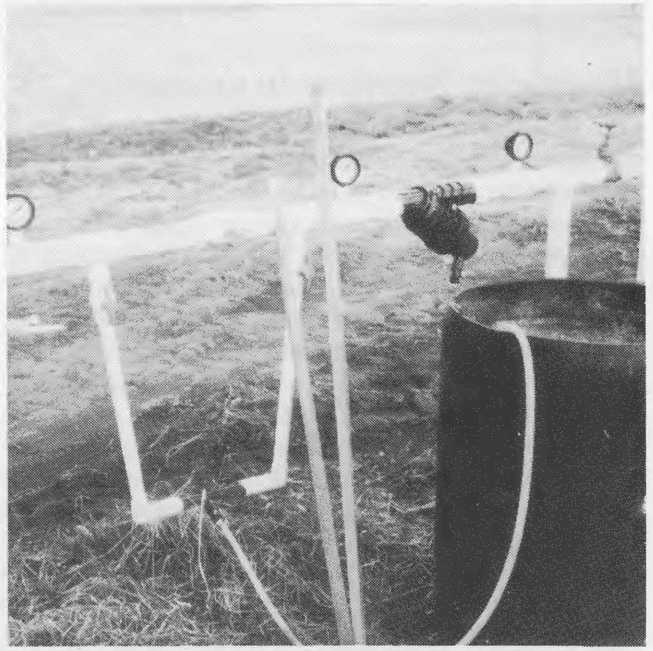
Liquid Feeding Program

To reduce labor costs, growers who are mass producing large numbers of plants are injecting soluble fertilizers into the irrigation water. This is most effective in conjunction with some slow-release fertilizers incorporated into the soil mix, but quality equal to any other program can be achieved by liquid feed alone if the irrigation and injection system is well engineered and the grower stays on top of the situation. However, with the concern for nutrient run-off and water quality, liquid feeding should be considered as a supplemental program to the slow-release fertilizers.

Some growers inject dilute fertilizers with a proportioner ("injectors") automatically at each irrigation (100 to 150 ppm N), the idea being that fertilizer needs by the plants closely parallels water needs. Others apply more concentrated solutions, generally at weekly intervals (250 to 300 ppm N), and reduce frequency of application or the concentration during fall and winter. Injectors are used to obtain the desired concentration of fertilizer dissolved into a concentrated stock tank and siphoned and diluted to the proper concentrations as it goes into the irrigation system. In this program the foliage is generally flushed with clear water to avoid potential leaf burn.

Growers need to evaluate and adjust for their particular mix, kind of plants grown, and amount of leaching from rainfall or irrigation.

Relatively inexpensive fertilizer sources can be used (calcium nitrate, ammonium nitrate, potassium nitrate, mono and diammonium phosphates, and phosphoric acid), enabling a grower to customize a formula. Several brands of soluble fertilizers are also marketed in several analyses. Completely soluble materials must be used or provision must be made to allow sludge and sediment to settle out or be filtered. Producers



Injectors are sometimes used for liquid fertilization and chemical application.

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*All rates listed are general guidelines to help in quantities required. These are **not** recommendations. Please refer to the label for specific rates.

need to be alert and to be familiar with methods of making up stock solutions for injectors. Great flexibility is possible with liquid feeding programs but more attention is required. Growers will need to adjust for the characteristics of their particular mix and kind of plants grown and to monitor the buildup of soluble salts. Monitoring with a pH meter and soluble salt meter helps to develop a good program and avoid problems.

Growers using a pine bark mix will find better results with most plants using the nitrate source of nitrogen ($CaNO_3$ + KNO_3) instead of an ammonium source of nitrogen (NH_4NO_3). If only azaleas or blueberries were grown, ammonium nitrate or ammonium sulfate would be acceptable nitrogen sources.

Iron and magnesium levels must be maintained in container production. If deficiency symptoms appear on the plants or if soil tests show low levels, soluble sources can be injected.

Some growers inject 50 pounds per acre of Epsom salts (magnesium sulfate) twice a month during the growing season. Do not add this to stock solutions containing calcium nitrate as this can cause the magnesium to become insoluble. Apply separately in this situation. Some growers add 8 to 12 percent chelated iron at 1 pound per acre with each fertilization to supply additional iron.

Another advantage of liquid feed systems for nurseries using proportioner type injectors is the opportunity to correct alkaline water by injecting sulfuric or phosphoric acid into the irrigation system to bring the pH just below neutral. However, this is an expensive process and should be avoided if possible during the site-selection stage.

Monitoring Nutrition in Containers

Plant growth and money has already been lost if you test only when nutritional deficiencies appear. A preventative program must be established. It may be impossible to monitor each variety of the plants you are growing. Choose at least one or two plants out of each of your major plant categories. These major categories may include conifers, broadleaf evergreens, deciduous shrubs, and trees and perennial plants. Sample on a biweekly schedule. Always take samples at the same moisture level in the containers. This can be accomplished by sampling 2 to 3 hours after irrigation. **Be consistent!** Sample at least every 2 weeks and monitor and record the soluble salts levels and the pH of the medium solution at each sampling. Take samples every 4 weeks or as needed and send to the Auburn University Soil Testing Laboratory or a private analytical service for full elemental analysis. If you have a nutritionally deficient plant, send a sample of its medium or extract, as well as a sample of medium from a healthy plant. This will allow you to start establishing deficiency levels of particular nutrients or excess levels of competing nutrients. Make a chart of soluble salts measurements so that you can visually track any trends.

Select five to ten plants from each group to study fertilizer rates. Use the recommended rate of fertilizer for the control group or the group to which other treatment groups will be compared. Increase the rate to 1½ or 2 times the recommended rates for the experimental plants. Make sure to record the fertilizer used, the rate of fertilizer applied, the name of the plant, the date applied, and who made the application.

Monitor the growth and the nutritional status of these plants and compare them to the control plants. Soluble salts readings can be taken on a regular schedule at the nursery and supplemented by submitting samples to the Auburn University Soil Testing Laboratory or private labs for full elemental analysis.

Auburn University is currently using the saturated paste extract method for extracting the media solution. This involves saturating a sample of container medium and allowing it to come to equilibrium. A vacuum is then applied to the saturated paste to extract the solution. The analysis is then performed on the solution. This procedure is effective but obviously very time consuming and expensive for a nursery. A procedure is outlined below that is much easier.

The soil lab provides a basic analysis for pH, soluble salts, nitrate and ammonium nitrogen forms, phosphorus, potassium, calcium, and magnesium. The lab has special forms for use by the nursery and floriculture industries and containers for sending in samples. Contact your county Extension office for forms and containers. Be sure to note that you are submitting a nursery or greenhouse medium and indicate the crop(s) being grown and the stage of its growth.

The established extraction method within the nursery for testing the nutritional status of container plants is a 1:2 ratio by volume of container medium and water. This method involves taking a sample of the container medium, adding twice the medium volume of distilled water, allowing the sample to equilibrate, pouring the sample through a sieve to separate the solution from the medium and, finally, analyzing for pH and soluble salts. This method was and is useful, but now there is a new method available that has many advantages over previous extraction procedures. This method is the Virginia Tech Extraction Method (VTEM), which is sometimes called the Pour-Through Method.

The Virginia Tech method of monitoring the nutritional status of container growth plants was developed by T. H. Yeager, R. D. Wright, and S. J. Donohue. The method enables the grower to easily monitor on a regular basis the soluble salts levels as well as the availability of various elements in the soil solution.

The method involves pouring distilled water on the medium surface and collecting the extract or leachate as it comes out of the holes at the base of the pot. VTEM has several advantages over previous procedures used by the nursery:

- VTEM closely reflects the actual soil solution to which the plant root is exposed.
- Slow-release fertilizer granules are not disturbed or ruptured because the medium is not removed from the container and the root systems are not disturbed during the extraction process.
- The time for collection and analysis of soluble salts is drastically reduced over previous methods, because no time is required for equilibration or lengthy preparation of soil samples.
- No specialized equipment is required and all collection testing can be done in the field.
- The extraction solution can be sent to the soil lab or other analytical laboratories for rapid analysis and reporting of nutrient levels in the samples. The soil lab normally has to prepare a saturated paste from the media samples that are sent in for analysis. By sending in an extract solution, the most laborious step is cut out of the procedure. Therefore, turnaround time is much faster.

The basic extraction procedure for the VTEM is as follows:

- The container with the medium in it is raised on two or three blocks of wood, several half-inch sections of PVC pipe, or some other suitable objects to lift the container bottom off the surface of the collection pan (Figure 3). The collection pans should be wide enough to collect the leachate from the center and the side holes of the container. Pie pans or plastic saucers are good for collecting the leachate.
- Sufficient distilled water is poured on the surface of the container medium so that about 2 ounces of water is accumulated in the collection pan. Distilled water can be purchased at your local grocery store for about 70 cents a gallon. Apply 2½ to 3 ounces of the distilled water to a 1 quart container. For 1 gallon and

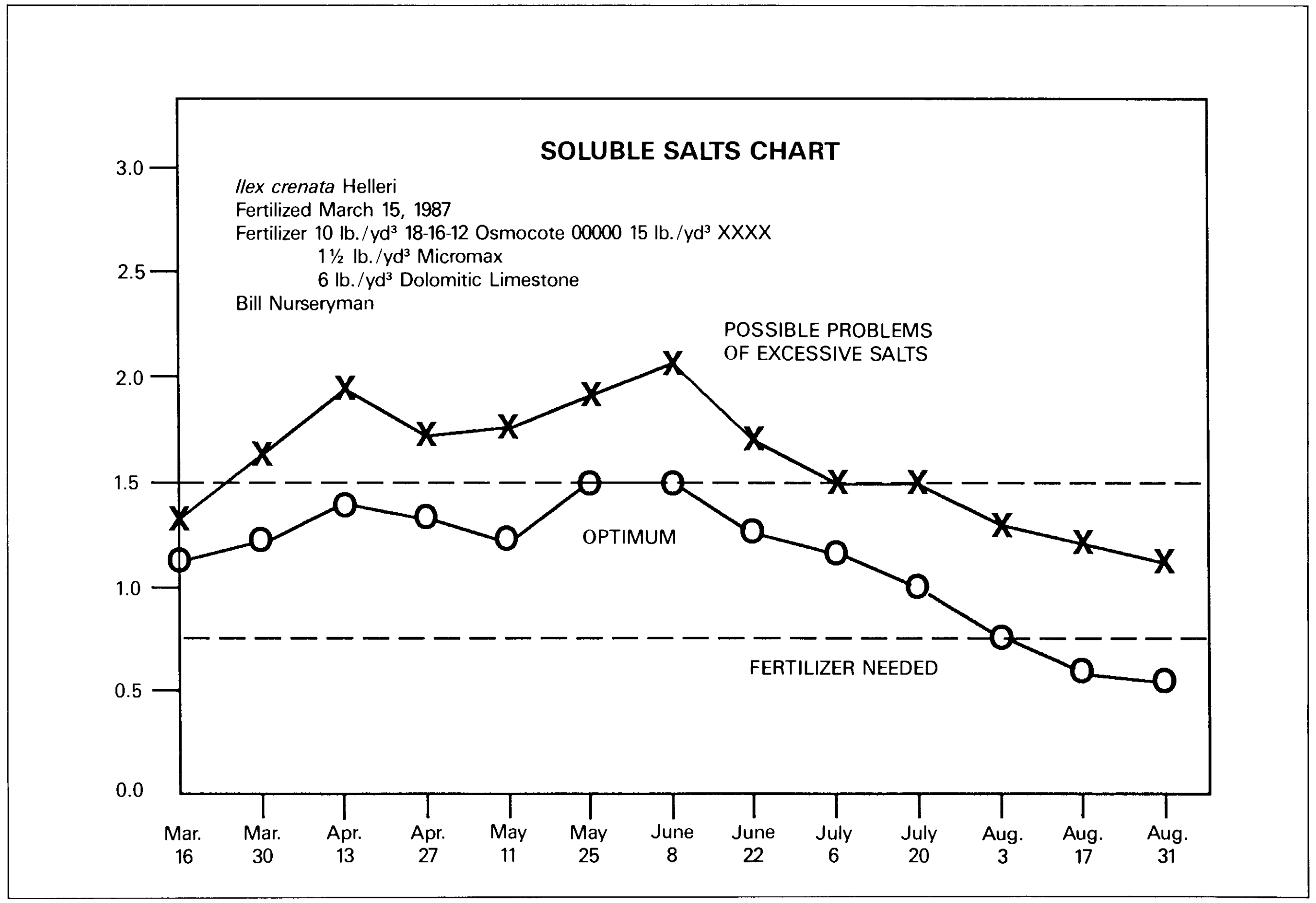


Figure 3. Fertility management chart. Slow-release fertilizers usually result in lower readings (1.0 or below) when using the Virginia Tech Extraction Method. Each nursery must establish its own standards over time. If one reading is exceptionally low, take several more samples a week later to verify and before adding more fertilizers. Some fertilizers have different formulations of nitrogen that release at different times. Sometimes there is a break of a week or two between the time that one fertilizer runs out and the other releases. Fertilizing early could result in excess fertilizer.

3 gallon containers, apply 12 to 12½ ounces, respectively. The moisture level in the containers should be at the same level each time samples are taken, because the moisture level of the container will influence the level of the nutrients extracted. A good way to maintain this consistency is to collect the samples when the level of moisture in the containers is at or near container capacity. This can be done by taking the samples 2 to 3 hours after irrigation. To get reliable, meaningful readings, it is very important to follow this procedure.

- All the leachate that is collected in the pie pans should then be poured into a plastic bottle or some other suitable container. The sample is then ready for pH, soluble salts, and nutrient analysis. Conductivity and pH meters are available so that samples can be analyzed on site. If a full nutrient analysis is required, the samples may be sent to a private analytical laboratory.
- Refrigerate samples that are going to be held for 2 or 3 days until time for the analysis. Samples that are to be held longer than this should be frozen.

The amount of research and data currently available on which to base recommended levels of nutrients in the leachate to provide optimum growth for various container grown plants is not extensive. Research done by Robert Wright on *Ilex crenata* Helleri and observations by growers and researchers under nursery conditions have shown the following levels to promote vigorous growth on many woody ornamentals. These levels can be used as general guidelines. "Optimum" levels for each crop can be developed over time with a good record keeping system. Recent testing of media containing slow-release fertilizers show that readings may be lower than those listed below. It is important that you test regularly andd establish your own standards.

Suggested Conductivity Readings For Various Types Of Nursery Crops Using Virginia Tech Extraction Method

Salt Sensitive	0.50-0.75 mMhos
Non-Sensitive	0.75-1.50 mMhos
Deciduous Plants	2.00 mMhos

Recommended Nutrient Levels For Container Grown Nursery Crops

Element	ppm in Leachate
N	75-100
P	10-15
K	30-50
Ca	10-15
Mg	10-15

Toxicity of minor nutrients should not be a problem if minor nutrients are added at recommended rates. The recommended levels for minor nutrients are: Fe, 2.000 ppm; Mn, 1.000 ppm; B, 0.200 ppm; Zn, 0.030 ppm; and Mo, 0.007 ppm.

Reference

Yeager, T. H., R. D. Wright, and S. J. Donohue. 1983. Comparison of pour-through and saturated pine bark extract N, P, K, and pH levels. *Journal American Society Horticultural Scientists* 108:112-14.

Winter Protection Of Container Plants In The Nursery

Alabama's **average minimum temperatures** place different segments of Alabama in hardiness zones ranging from Zone 7 to Zone 9. Weather in Alabama and other states is "normally abnormal." Plants and money are lost many years in Alabama by planning for the "normal winter." To establish a successful nursery business in Alabama, the owner or manager must plan for the extremes and hope the extremes do not exceed "normal."

A major objective of any nursery producer is to grow a quality plant as fast as possible and sell it. This goal of achieving optimum growth potential does not always coincide with the unpredictability of nature's whimsical early and late freezes and Indian summers. Unlike the floriculture business, where plants are produced and sold in times as short as 4 to 6 weeks, production of nursery crops normally involves taking plants through at least one winter.

Through understanding of some basic physiological aspects of plant responses to cooler temperatures and adaptive mechanisms for winter survival, economical precautions can be chosen to help the plant not only survive but be ready to initiate vigorous, active growth in the spring.

FREEZING INJURY. Freezing injury results from extracellular (outside the cell) and intracellular (within the cell) freezing at temperatures below 32 °F.

Extracellular freezing is a result of slow freezing or mild supercooling and is a response common to all plants in temperate climates that experience freezing temperatures. Injury is not always associated with freezing. The extent of injury depends on how low the temperature drops, rate of decrease, duration of low temperature, and predisposition and physiological state of the plant. Symptoms include: reduction in growth, chlorosis, bronzing, puckering, crinkling, and death of the leaves. Symptoms on stems include: cankers, cracking, splitting, and dieback.

Plant cells are encased in rigid cell walls. Injury results from freezing of water in the spaces between the cell membrane and cell wall. Frozen water is not available for use by the plant. As available water freezes, the remaining unfrozen water outside the cell increases in the concentration of elements within the water. In response to this high concentration of salts outside the cell, a flow of water with lower salt concentration comes within the cell until the two sides are of equal strength. Higher salt concentration lowers the temperature at which water turns into ice. This is a protective mechanism. As the freezing process continues, water continues to move out of the cell and dehydration occurs. This can lead to death of the tissue or the plant. The avoidance of this damage lies in the plant's ability to prevent this water loss.

Nurseries in North Alabama must protect plants with overwintering houses or by pulling plastic over plants.

Intracellular freezing or freezing water within the plant cell involves a rapid drop in temperature, causing freezing of the water in the cell. The crystal structure of the ice pierces the membrane around the cell. When water movement from within the cell is not fast enough to keep pace with the freezing of water outside the cell, ice begins to form in the cell. Once the process begins, it occurs very rapidly and death results.

The following points are the most important factors in preventing freeze damage:

- Moderate temperatures to prevent freezing.
- Keep plants dormant.
- Maintain adequate moisture in the plant by reducing water loss and providing adequate water to the plants.
- Select plants that are hardy and suited to the location.

MOISTURE. Irrigation is one of the least exact of all cultural practices in the nursery. Researchers are concentrating on this area, but to date technology has not advanced to the point of delegating this important job to an inexperienced employee. Experience is still the best teacher for this cultural practice.

Too much or too little water during the latter part of the growing season can promote or prevent hardening-off of nursery crops. Irrigation should be reduced in the fall but not drastically. Research indicates that plants receiving reduced irrigation are better able to withstand winter temperatures than those that are allowed to dry out. Wind breaks help prevent water loss. Some plants have a natural defense mechanism against water loss, closing of the stomates (openings in the leaf surface) or curling up of the leaves to reduce the surface area exposed to the wind.

LIGHTING. Day length activates physiological processes that prepare plants for winter. Plants should be fully hardened before moving to overwintering shelters. Some nurseries remove shade in the fall to speed up the winter conditioning. Supplemental lighting that promotes long days and continued growth is turned off. Nurseries usually begin covering houses or preparing for overwintering in Alabama a little before or shortly after Thanksgiving.

PRUNING. Allow at least 6 weeks before the average first frost date to prune. Late pruning may stimulate bud break. Any tender growth not sufficiently hardened-off to withstand cold temperatures may be killed or tender bark of the stems may split.

TEMPERATURE. As the day shortens and temperatures become cooler in the fall, plant growth slows and plants begin to go dormant. This is a slow, gradual process. An early hard freeze can be too drastic for the plants to endure. A few early mild frosts help plants to physiologically progress to a dormant state.

High spring-like temperatures in December or January can cause the hardiness process to reverse and expose plants to damage. This is a common occurrence in Alabama.

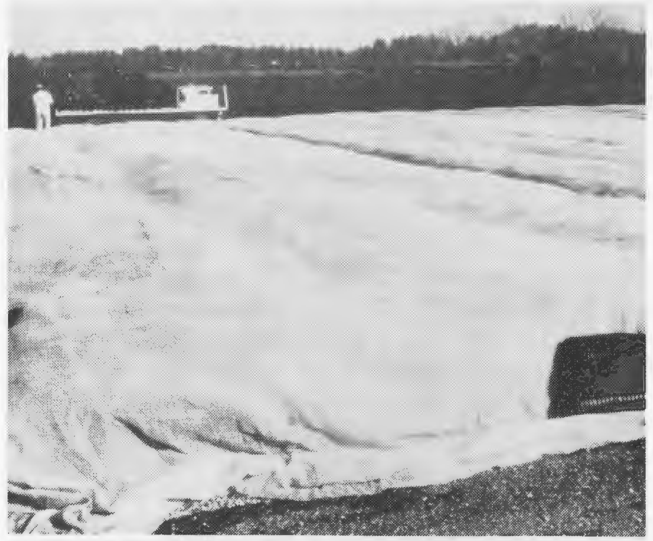
HARDINESS. Roots are usually killed or damaged at a much higher temperature than aboveground parts of a plant. Placing a plant in a container exposes roots to temperatures much lower than would normally be experienced in the ground. A plant that would normally be killed at 0 °F in the landscape may be killed at 20 or 25 °F in a container. The difference between the container temperature and the ambient temperature is 3 to 5 °F. Generally, there is a hierarchy for hardiness of various plant parts with flowers and roots being the most tender parts.

Not all plants can tolerate the same degree of cold. Through observation and testing plants have been loosely rated for cold hardiness and placed in a Hardiness Zone classification to aid nurserymen, landscapers, and the public in selecting plants that will survive under normal winters.

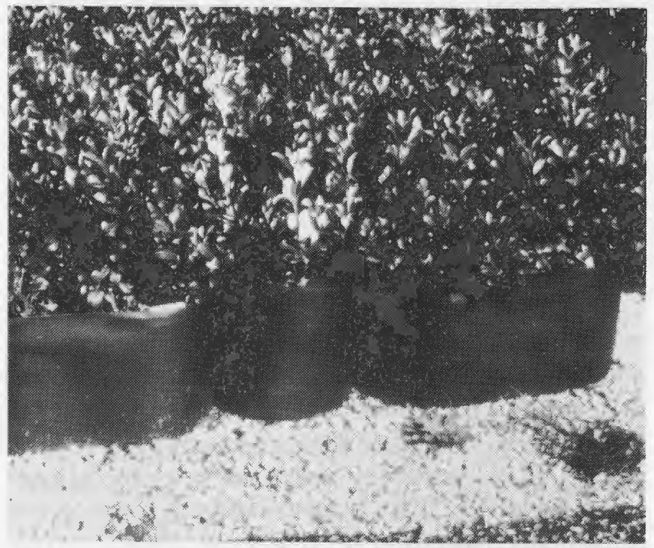
ROOT HARDINESS. Some research has been done on the root hardiness of various ornamental plants by E. J. Studer and others at Cornell University and J. R. Havis at the University of Massachusetts. This work is being continued by a number of researchers across the country. Examples of some of the more tender plants and the root-killing temperatures for them include:

Botanical Name	°F
Buxus sempervirens	27
Cornus florida	22
Cotoneaster congestus	25
Euonymus alata	19
Euonymus fortunei Vegetus	23
Ilex crenata Helleri & other Japanese hollies	23
Ilex x Nellie R. Stevens	23
Mohonia bealei	23
Viburnum plicatum var. *tomentosum*	20

Create space for testing new products or establishing overwintering requirements.



Central and South Alabama can use tobacco cloth or other less expensive methods for hardier crops.



Jamming containers together and wrapping perimeter containers is sufficient for most crops most winters in Coastal Alabama.

EFFECTS OF FERTILIZER. Plants under a well-balanced fertilizer program have a greater chance of coming through winter in good health. Nutritional programs using quick release soluble or granular fertilizer need to cease fertilization by mid-September. Slow-release fertilizer programs need to be timed carefully so plants will not be forced to continue succulent, tender growth late into the season. This would prevent the hardening process and expose the plant to freeze injury.

Temperature, moisture, pH, microbial activity, and other factors control the availability of slow-release fertilizers. The grower has little control over many of these factors, so timing becomes very difficult. Often a combination of slow release and soluble fertilizers provides the most controlled program.

Wait until plants are fully hardened in late November or December before applying fertilizer. Low rates of fertilizer should not force plants to break dormancy. **Do not let plants dry out!** Warm winter days cause excessive release of some slow-release fertilizers. If plants dry out under these conditions, salt concentration increases and may burn the plant. Monitor moisture and temperature levels through the winter. Irrigate to leach excess salts.

FIELD VS. CONTAINER. Problems in field production usually result from plants that are marginally hardy to an area or to temperatures dropping below normal. Low lying areas that create "frost pockets" increase chances of these low temperatures. Windy areas enhance dessication of plants. Wildlife winter feeding is also a problem of field and container nurseries. Roots are insulated in the soil from temperature extremes, so this is not usually a problem with plants that are hardy to the area in normal winters.

Container-grown plants have greater susceptibility to winter freezes and damage because of exposure of less hardy roots to low temperatures and to limited water-holding capacity of container plants compared with field nursery stock. Water is usually available to field plants because roots extend below where water is frozen. Water in containers is exposed so that the entire medium volume may freeze.

During bright, sunny, cold days, broadleaf plants transpire water into the surrounding dry air. If water is frozen in the container it is unavailable to the plant and the plant will be injured or die from dessication.

WINTER PROTECTION OF PLANTS IN CONTAINERS. Reducing the exposure to low temperatures and dessication is one way of attacking the problem of freeze damage.

A number of actions can be taken for minimum protection. The following precautions are ranked in order of their effectiveness for winter protection. There is no question that one of the methods will provide adequate protection. However, the problem comes with selecting the most economically effective method to use to reduce costs and increase profits.

1. The least effective method is to do nothing, leave the plants spaced, and provide irrigation during the winter (not an alternative in Alabama).
2. Jam the plants together.
3. Jam the plants together and surround the outside with plastic or a row of pots filled with bark.
4. Heal the pots in with some type of mulch such as straw or saw dust.
5. Add shade and windbreaks to any of the above precautions.
6. Cover the plants with some type of material or combination of materials to trap the stored ground

heat. These materials include: shade cloth, tobacco cloth, white poly, and thermoblankets.

7. Use overwintering houses with clear poly.
8. Use overwintering houses with white poly.
9. Use overwintering houses with double poly.
10. Use above measures with a layer of poly over the plants in the houses.
11. The final resource is to add supplemental heat.

The method you select depends on your location within the state, microclimates of your nursery, the plants you are producing, and the amount of risk you feel comfortable taking.

The choices in north Alabama are relatively easy. Producers know that they must use some form of covered protection. The choices of central Alabama are not so easy. They must provide some covered protection for the cold-sensitive hollies, nandinas, dogwoods, etc., but may take a chance or **be ready** to cover viburnums, shore junipers, euonymus, etc. Nurserymen of south Alabama need to jam all plants and **be ready** to provide additional protection to tender plants.

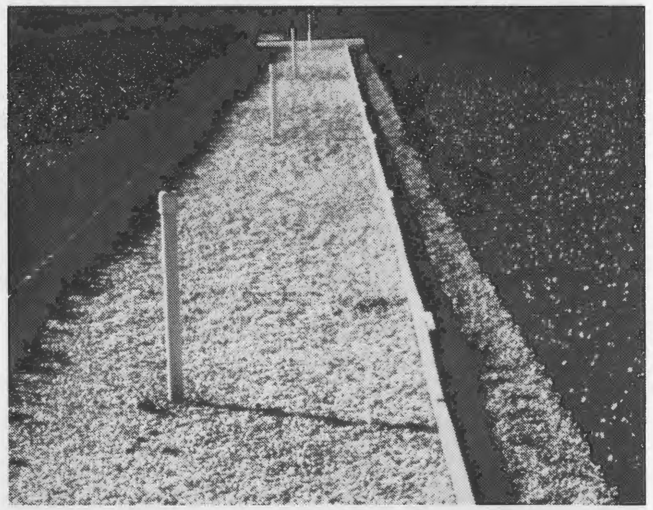
Overhead irrigation can provide some protection. A sheet of ice forms over all the leaves, which acts as insulation from colder temperatures. Heat is released as water freezes. This is only effective if temperatures drop to freezing for periods of time less than about 12 hours. However, this may be an alternative to reduce damage from an early freeze.

A practice of some nurserymen is to place containers pot to pot under the shade of pine trees with a mulch all around the pots. This does offer fair protection. Shade provides a windbreak and light reduction, which reduces water loss from transpiration. Mulch provides some insulation from heat loss and reduction of moisture loss from the containers. Although this offers fair protection, it will not be sufficient for a cold winter in northern or central Alabama.

A method introduced in Maryland that has proven successful in Alabama is the use of thermoblankets. This material comes in large rolls (7 to 9 feet wide x 100 to 250 feet long), and is made of plastic with encapsulated air bubbles to provide insulation. On a cloudy day, the temperature inside a poly-house is almost as low as the ambient temperature outside the house. The only available heat is from stored heat in the soil. By placing a covering of some material directly over the plants (white plastic has also been used successfully), better utilization can be made from available soil heat.

The plants should be watered well (dry soil freezes much faster than wet soil), sprayed with a fungicide combined with a surfactant, jammed together (tall plants should be placed on their side), and covered with the thermoblanket. White 4- or 6-mill poly goes over the top of the thermoblanket. The edges are anchored with sand, gravel, or large boards to prevent excessive flapping of the material during strong winds. Straps across the plastic provide additional protection against the wind.

The thermoblanket provides good protection but with this method comes some unique problems. Heat build-up during bright winter days can allow buds to break prematurely, making them more susceptible to winter damage. Proper timing for covering and uncovering is very important. Another problem is from mice or other rodents. If one to two mice get under microfoam, the damage can be devastating. Rat poison must be placed under the thermoblanket. One final limitation of this method is the obvious limited access to plants.



One nursery designed permanent nailing strips so plants could be jammed and covered quickly.

The most reliable overwintering practice in Alabama is polyethylene-covered hoophouses. Clear or white poly is used, but evidence indicates that although night temperatures are almost the same under white and clear poly, temperatures remain lower under white poly on sunny days. This prevents early bud break. Even with this degree of protection, root sensitive plants cannot withstand prolonged night temperatures of 0 °F or lower combined with day temperatures reaching only 20 °F. Additional protection in these extreme temperatures requires double poly covering inflated by a small fan to give additional insulation, covering plants inside the house with one layer of white poly or microfoam or the use of supplemental heat. The temperature in these houses must be monitored and provisions for ventilation designed into the structures. With ventilation comes water loss from the plants. Whenever venting is necessary, irrigation is also required. If possible, houses should be oriented in a north-south direction to aid in the prevention of excessive heat build-up.

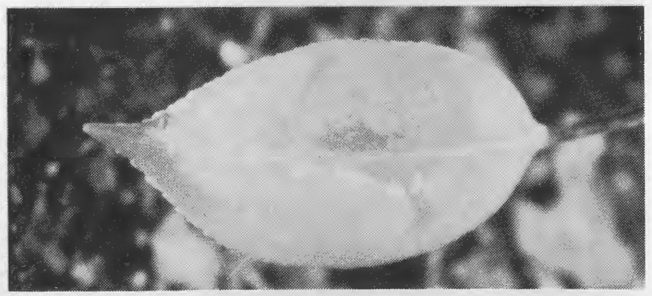
The above procedures have been known and used for a long time. On the horizon are some new ideas that may provide good protection at lower costs. One innovation is square pots designed for intimate contact with the soil that allow better use of the heat storage in soil. Another is control of bacteria that serve as nucleation agents for ice crystals in plant cells. By preventing ice formation, problems of dehydration may be reduced. Insulated containers have also been developed that are now going through the evaluation stages and being subjected to cost/benefit analysis.

You can get instant access to weather information through your computer by calling a toll-free number. The Alabama Cooperative Extension Service provides this information. It is an extremely valuable resource. You can get not only a typical weather preediction but also a prediction of the number of hours temperatures will remain below 20 °F. Other information is also available. Call your county Extension agent for more information.

To produce quality plants and avoid excessive losses of plant material by freeze damage in Alabama, some form of overwinter protection is required. It should be considered as part of the production program for producing container plants in Alabama and included in your budget.

Water Quality

Many new nurseries have struggled because of poor quality water sources. Irrigation water offers traces of certain minerals that you need to consider when developing a nutrition system. It is important to know these levels so the fertilization program can be adjusted. For example, if the water contains a high calcium content, less calcium would be added to the medium in the fertilization program.



Calcium deposits on leaves caused by water with high alkalinity.

Test water before purchasing land to be used for a container nursery. If good-quality water is not available, it is usually not economically feasible to modify it for irrigation. A number of labs provide water testing service.

The following table can serve as a guide to nutrients tested and acceptable ranges for various water quality parameters.

Parameters That Should Be Tested And Desirable Ranges For Specific Elements In Irrigation Water

Phosphorus (P)	0.005-5.000 mg/l
Potassium (K)	0.500-10.000 mg/l
*Calcium (Ca)	40.000-120.000 mg/l
*Sulfate (So$_4$)	24.000-240.000 mg/l
Magnesium (Mg)	6.000-24.000 mg/l
Manganese (Mn)	0.500-2.000 mg/l
Iron (Fe)	2.000-5.000 mg/l
*Boron (B)	0.200-0.800 mg/l
*Copper (Cu)	0.000-0.200 mg/l
SAR	0.000-4.000 mg/l
*Soluble Salts	0.000-1.500 mmhos/cm
Zinc (Zn)	1.000-5.000 my/l
*Sodium (Na)	0.000-50.000 mg/l
Aluminum (Al)	0.000-5.000 mg/l
*pH	5.000-6.500 mg/l
Molybdenum (Mo)	0.000-0.020 mg/l
Chloride (Cl)	0.000-140.000 mg/l
Fluoride (F)	0.000-1.000 mg/l
Nitrate (NO$_3$)	0.000-5.000 mg/l
Ammonia (NH$_4$)	undetermined
*Alkalinity	0.000-100.000 mg/l CaCO$_3$

*Key parameters to be considered.

The SAR value refers to the Sodium Absorption Ratio. This value quantifies sodium levels in relation to calcium and magnesium levels in the water.

We are fortunate in Alabama to have abundant, high-quality water resources in most areas. However, container production is a very expensive business. You want to make sure your water source is adequate to grow high-quality plants. Have your water tested for both quantity and quality before you buy property or begin your business.

Auburn University has a water testing service. Other labs available to test your water are listed below. Call and compare prices before choosing a lab.

A & L Laboratories
411 N. Third Street
Memphis, TN 38105
901/527-2780

Ohio Agricultural Research and Development Center
Research & Extension Analytical Lab
Wooster, OH 44691
216/263-3760

Soil Test and Plant Lab
University of Georgia
2400 College Station Road
Athens, GA 30605
404/542-5350

W. R. Grace & Company
P. O. Box 789
570 Grant Way
Fogelsville, PA 18051
215/395-7104

Woody Ornamentals Insect Pest Management

Patricia P. Cobb, *Extension Entomologist*

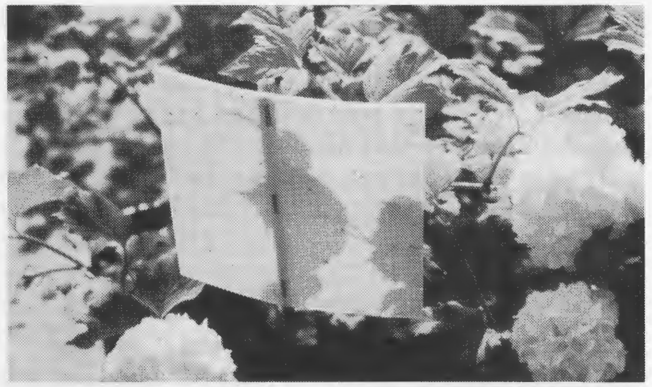
A variety of insect and mite pests in Alabama may infest woody ornamentals in production situations. Regular inspection of plant material and accurate record keeping of observations, plant conditions, and management practices are essential parts of successful pest management programs. When control efforts are necessary, proper timing of actions is often as important as choice of control. The following steps may be helpful in establishing pest management strategies for production woody ornamentals, whether grown in containers or field grown:

1. Keep up-to-date files on potential pests, pest life cycles, and control recommendations. Find out from Extension and research professionals what pests are more likely to present problems on the crops that you grow. Gain as much information as possible about what environmental conditions favor the development of certain pest populations.

2. Select a staff member or hire someone to be a "scout." This person should be dependable, trustworthy, and trainable. A scout monitors plants on a regular basis and keeps records of observations. The scout must be able to recognize common pests and seek help in identifying the uncommon pests that may be encountered. From records of these observations managers decide when and how to take control actions. Extension professionals can provide information on resources available for selecting and training scouts. It is not unusual for nurseries that scout crops to save money in insecticide costs because treatments are timed more precisely to vulnerable pest stages before extensive damage is done.

3. Management and cultural practices are usually extremely important in effective control efforts. For example, insects and mites may move from weedy fence rows or field borders onto nursery stock. Good sanitation in and around growing sites includes weed control. Abandoned plant dumping sites often harbor insect infestations, and "unmonitored" stock plants can supply pests to propagation areas. Plants that are stressed by drought, poor nutrition, etc., may be more attractive to pests, such as borers, than those that are well maintained. "Held over" plants that develop scale insect or whitefly problems can sometimes be pruned to remove part of the insect population.

4. An insect pest problem may require chemical treatment. Preventive treatments are not recommended. Preventive treatments often result in missing the vulnerable pest stage completely or extra costs in labor and materials. Money is best spent on a regular monitoring program than on preventive treatments.



Regular monitoring for insects and disease can save money on insectcides and crop damage.

When treatment is required, consider carefully control alternatives. Plants grown outside may receive some benefit from the naturally occurring complex of parasites and predators that help to keep pest populations down, especially in the spring. "Biorational" insecticides such as insecticidal "soaps" and oils are effective in controlling or suppressing low populations of mites, whiteflies, and aphids in the spring; *B.t. (Bacillus thuringiensis)* products are effective in controlling many kinds of young caterpillar pests. Use of these products in the spring may buy some time before "harder" insecticides are used. This means that maximum benefit from parasites and predators is realized, and pest resistance from repeated pesticide use is delayed.

5. Evaluate control programs to determine effectiveness and costs. Some of the newer insecticides are designed to be most effective on certain pest life stages. Ineffective controls may be due to improperly timed treatments.

Pesticides that do not contact pests are usually wasted. Good coverage is essential to good control. If containers are packed together too closely, and if sprays are not penetrating the plant canopy, pests may not be controlled. For example, lace bugs are often a problem on container azaleas. Lace bugs are easily controlled with insecticides, but if the spray does not reach the leaf undersurface, lace bugs may not be controlled. These insects remain on the undersides of leaves. "Red spiders" are spidermites that in low numbers are usually found on leaf undersurfaces. As populations increase, mites move to other plant parts. Controlling an early stage mite population may depend as much on good coverage as choice of miticide.

Insects are not the only pests of container nurseries! Deer, voles, moles, rabbits, mice, and others can be serious problems. Call your county Extension office if problems occur.

For life cycle information on specific pests, contact your county Extension agent. Publications are available that provide more information on common pests of ornamentals. Circular ANR-500, "The Alabama Pesticide Handbook," includes specific pesticide control recommendations for commercially grown woody ornamentals pests.

Weed Control In Container Nurseries

Planning for weed control is extremely important if you are going to produce a quality plant. Poor planning in this area is also very expensive. Poor timing or ineffective application of chemicals results in hand weeding, which is a costly and very frustrating chore. Many new and old nurseries learn this lesson the hard way.

One way to develop a weed control program is to look at what other container growers in Alabama are doing. Dr. Charles Gilliam, Bill Foster, Dr. Ron Shumack, and Dr. John Adrian surveyed nurseries throughout Alabama to determine what products and procedures the industry was using.

The survey team found that growers make an average of three applications annually of Rout, Ronstar, or OH_2 herbicides for container weed control. Where there was a concern for sensitive plants, Ronstar was the chemical chosen. Pennant and Southern Weedgrass Control had some use. Snapshot, a new granular product for containers produced by Dow/Elanco, has proven to be effective and safe on tender plants like some azaleas, hostas, daylilies, liriope, and others. This chemical will get increased use in the future.

The greatest weed problems indicated by the nursery producers and the ones not controlled by some of the herbicides included: prostrate spurge, oxalis, nutsedge, and eclipta.

The cost of weed control in the survey was $246 to $567 per acre for hand weeding. Add this to $566 for three applications of a preemergent herbicide like Rout, and the cost of the total weed program rises to $800 to $1,100 per acre. This compares to $3,600 per acre for hand weeding without the use of preemergent herbicides.

Surveyed nurseries controlled weeds under containers with black plastic, weed mat, rock or shell, or combinations of treatments. Princep and combinations of Princep with other preemergent herbicides were used for chemical control.

A conscientious weed control program using a combination of chemical and sanitation practices obviously saves money, but increased growth and quality of the plants provides the greater benefit of a good weed control program.

Circular ANR-465, "Weed Control For Nurseries," is available from your county Extension office to help you select the product best suited to your particular needs.

Remember that some chemicals are restricted and, to purchase them, you must have a valid certified pesticide applicator license. Contact you county Extension agent if you don't have the proper qualifications.

The Business Of Nursery Business

A major weakness in many new as well as established nurseries is developing and following a good business plan. Many people enter the nursery business because of their love of plants. They become excellent growers, but the business fails because of lack of capital, poor management, or other poor business practices. A resource that is not often utilized is Alabama's Small Business Development Consortium. The office provides a team of consultants who can work with you one-on-one, providing, at no cost to you, assistance and information on:

Starting A Business
Business Planning
Accounting
Record Keeping
Advertising and Promotion
Financing
Personnel Planning
Inventory Control
Cash Flow Analysis
Exporting and Importing
Sales Techniques
Marketing Research
Computer Feasibility
Engineering and Research
Government Procurement
Patent Process
Technology Transfer
Others. . . .

If you have trouble with some of these areas or if you don't know what they are, swallow your pride and contact one of the Alabama Small Business Development Centers listed below.

The University of Alabama at Birmingham
Small Business Development Center
901 South 15th Street
UC Building #4, Room 143
Birmingham, AL 35294
205-934-6760

The University of North Alabama
Small Business Development Center
School of Business
Florence, AL 35632-0001
205-760-4234

Northeast Alabama Regional SBDC
Alabama A&M University and
The University of Alabama in Huntsville
225 Church Street N.W.
Huntsville, AL 35804-0343

Alabama High Technology Assistance Center
The University of Alabama in Huntsville
101 Morton Hall
Huntsville, AL 35899
205-895-6409

The University of South Alabama
Small Business Development Center
College of Business/Management Studies
Mobile, AL 36688
205-460-6004

Alabama International Trade Center
The University of Alabama
Box 870396
Tuscaloosa, AL 35487-0396
205-348-7621

The University of Alabama
Small Business Development Center
Box 870397
Tuscaloosa, AL 35487-0397
205-348-7011

Auburn University
Small Business Development Center
226 Thach Hall
Auburn University, AL 36849-5243
205-844-4220

Troy State University
Small Business Development Center
Sorrell College of Business
Troy, AL 36082-0001
205-566-7665

Alabama State University
Small Business Development Center
915 South Jackson Street
Montgomery, AL 36195
205-269-1102

Jacksonville State University
Small Business Development Center
College of Commerce and Business Administration
Jacksonville, AL 36265
205-231-5271

Livingston University
Small Business Development Center
Station 35
Livingston, AL 35470
205-652-9661, ext. 439

Certification Program

Contact the Alabama Department of Agriculture, Plant Industries Division (800-321-0018) before selling any plants or as soon as you have plants in production. Let them know that you are beginning a wholesale container nursery. This is a requirement and a benefit to you and others.

The nursery certification program was established in 1905 to restrict and control the entry and movement of plants or plant materials that could introduce or spread plant pests. It is important for our state as well as others to try to confine destructive pests such as fire ants, Japanese beetles, nematodes, and other diseases and insects that can adversely affect our environment.

You must be knowledgeable of proper storage, use, and recording procedures for pesticides.

Plant inspectors can help you recognize problems before they get out of hand as well as save you money. Any diseased plants shipped to other states can be inspected and returned or destroyed at your expense if regulated pests are discovered. If you want to be in this business, you want to develop a reputation as a conscientious professional. Be sure to contact Plant Industries early for their help and support.

Reference Books

Nursery Industry and Management

Container Growing by James Patterson, 174 pages. The late James Patterson of Patterson's Nursery, Albany, Georgia, wrote this excellent book of interest to producers. It is still considered the best book on the subject, even though some areas such as fertilization are becoming outdated. Available from American Nurseryman Publishing.

Nursery Management, Administration, and Culture by Harold Davidson and Roy Mecklenburg. Gives both general and specific information for making sound nursery management decisions. The authors give a detailed review of each phase of operating a production nursery. Liberally illustrated with photographs and tables and indexed. 464 pages. (1981). $27.95. Prentice-Hall.

The Modern Nurseryman by John Stanley and Alan Toogood. Sections on planning a nursery, stock plant management, and propagation and production systems. Deals with raising plants by a variety of methods. Chapters on rooting cuttings in cold frames, hardwood cutting with or without heat, layering rootstocks, grafting, budding, and future trends in propagation. Section on container growing systems looks at types of containers, growing media, potting systems, standing grounds, protected growing management, and tree production. 432 pages. (1981). Softbound, $22.00; hardbound, $45.00. Faber and Faber.

The Container Plant Manual by John Edmonds. A guide for the commercial production of container-grown stock. Discusses some of the more important points that control the production of container plants. 17 pages. (1981). $19.95. State Mutual Book.

The Commercial Production Of Climbing Plants by Phillip McMillan Browse. About growing climbing plants and some systems of production. Chapters devoted to containers, composts, support and tying, and irrigation, feeding, and weed and pest control. Alphabetical list of more than 50 genera. Each genus described in considerable detail, including instruction on propagation and cultural care. Charts and black-and-white photos. 98 pages. (1981). $22.50 International Scholarly Book Service.

Container Nursery Design by Dr. Bonnie Lee Appleton. Provides an outline for the design and establishment of a container nursery. 120 pages (1986). Amerian Nurseryman Publishing.

Container Growing Of Woody Ornamental Nursery Plants by R. D. Dickey, E. W. McElwee, C. A. Conover, and J. N. Joiner. An Agricultural Experiment Station Bulletin describing all phases of container growing: propagation, growing media, fertilization, irrigation, weed control, mechanization, pruning, grades and standards, inventory control, and cost of production. Department of Ornamental Horticulture, University of Florida, Gainesville, FL. Bulletin 793. 122 pages. (1978). No Cost.

Producing Plants In Containers by Carl E. Whitcomb. Provides a wealth of experiments and experience on container growing, provides practical solutions to problems in nurseries and greenhouses, and those growing plants in containers will find the book useful. 640 pages. $29.50. Lacebark Publications.

American Standard For Nursery Stock. Details height, caliper, branching height caliper relationships, root spread, recommended B & B specifications, etc., used in buying and selling field-grown nursery plants. 30 pages. (1990). $4.00. American Association of Nurserymen.

Environmental Plant Production And Marketing by Tokuji Furuta. Discusses aspects of container plant production that have been used in the U.S. and overseas. Production, management, and decision making for small-, medium-, and large-volume operations specializing in container-grown environmental plants. 232 pages. (1974). Cox Publishing.

Plant Materials

Hillier's Manual Of Trees And Shrubs by Hillier and Sons, Winchester. England. Descriptions of more than 8,000 plants representing nearly 700 genera, with information as to size, color, and habit. Sections on nomenclature and classification, planting, pruning, and garden planning. Illustrated glossary. 575 pages. (1983). $14.95. Van Nostrand Reinhold.

Hillier Color Dictionary of Trees and Shrubs by H.G. Hillier. More than 600 color photographs accompany succinct descriptions of 3,500 trees, shrubs, climbers, and conifers. Facts and advice on understanding plant names and classifications, choosing trees, shrubs, climbers, and conifers for particular purposes and locations, pruning, etc. Special 16-page section gives growth condition required and flowering time (indicated in months). 324 pages. (1984). Softbound, $19.95; Hardbound, $29.95. Van Nostrand Reinhold.

Know It And Grow It II: Guide To The Identification And Use Of Landscape Plants by Carl E. Whitcomb. Prepared originally as a guide to identifying and using landscape plants in the South, this book has been expanded and revised to include the United States and Canada east of the Rocky Mountains. The book is intended to assist nurserymen and landscapers interested in using woody plants in the landscape. This revised edition contains nearly 300 more pages, 1,600 black-and-white photos. Hardiness zone maps are included. 720 pages. (1983). $31.95. Lacebank Publications.

Photographic Manual Of Woody Landscape Plants by Michael A. Dirr. Provides brief descriptions of various plants while photographically depicting form and other ornamental characteristics. Each photograph is keyed numerically to the text for easy reference. The concept is to introduce the reader to the typical growth habit and prominent ornamental characteristics of particular plants, through text and illustration. 378 pages. (1978). Softbound, $14.60, Hardbound, $22.00 Stipes Publishing.

Manual Of Woody Landscape Plants by Michael Dirr. Identifies more than 1,100 plant species and 2,000 cultivars. Each plant has line drawings accompanied by information on hardiness, growth rate, habit, texture bark, culture, diseases, insects, cultivars, propagation, flowers, fruit, foliage size, color, and uses for the landscape. Softbound, $45.80, Hardbound, $33.80 Stipes Publishing.

Woody Ornamentals: Plants And Problems by R. E. Partyka, J. W. Rimelspack, B. G. Joyner, and S. A. Carver. Reference guide for nurserymen and students. Discusses plant parts and their functions; looks at disease and insect problems and physiological disorders and chemical injuries; tells how to look for and avoid plant problems. Glossary, subject index, and indexes to common and botanical plant names. Includes two appendices. Illustrated; 427 pages. $27.00. Hammer Graphics.

The National Arboretum Book Of Outstanding Garden Plants by Jacqueline Heriteau. A guide to the best landscape plants of North America. Covers ornamental plants; annual and perennial plants, bulbs, herbs, aquatic plants, ornamental grasses, ground covers, vines, shrubs, and trees. The book categorizes the plants by their landscape use. Contains many of the new cultivars released by the National Arboretum. Hardcover, $40.00. American Nurseryman Publishing.

Manual Of Cultivated Broad-Leaved Trees And Shrubs, Vol. I by Gerd Krussman. First of a 3-volume work on all the trees and shrubs cultivated in North America, Europe, Asia, Africa, and Australia and New Zealand. Contains approximately 500 pages, 400 photographs in 176 plates, and more than 500 line drawings. A total of 5,400 species and 6,004 cultivars in 796 genera will be included in the 3-volume set. Approximately 500 pages. (1984). $65.00. Timber Press.

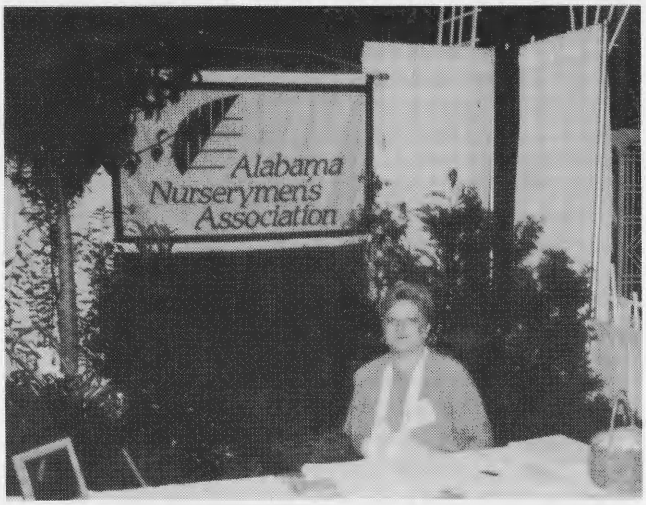
Diseases Of Shade Trees by Terry A. Tattar. Guide to the diagnosis, treatment, and control of tree diseases. Three sections deal with infectious diseases, their causal effects, spread, and treatment; non-pathogenic conditions often mistaken for diseases and hazardous trees due to structural weakness. Illustrated, glossary of terms. 361 pages. $24.50. Academic Press. San Diego.

Westcott's Plant Diseases Handbook, 4th ed., by Dr. Cynthia Westcott. Guide to the diagnosis and control of 2,100 diseases that affect trees, grasses, shrubs, flowers, and vegetables. Almost 1,100 host plants are discussed. Descriptions of diseases caused by bacteria, fungi, viruses, nematodes, and non-parasitic factors such as nutrient deficiencies. Many newly reported diseases are listed, and most recent findings on nematodes and viruses have been incorporated. Chemicals brought up to date; and a directory for obtaining chemicals is included. 74 illustrations; 803 pages. (1979). $39.50. Van Nostrand Reinhold.

Diseases And Pests Of Ornamental Plants, 5th ed., by P. P. Pirone. Descriptions of diseases and pests of nearly 500 genera. Detailed instructions on fungicides, insecticides, other controls, and equipment are included. 237 illustrations; 566 pages. (1978). $32.50. John Wiley.

Insects That Feed On Trees And Shrubs by Dr. Warren T. Johnson and Howard H. Lyon. An aid for nurserymen, arborists, landscape gardeners, regulatory officials, or students for diagnosing plant disorders caused by pests and identifying the pests responsible. 212 full color plants and 32 black-and-white photos. 464 pages. (1976). $47.50. Comstock.

Disease Of Woody Ornamental Plants And Their Control In Nurseries by Ronald K. Jones and Robert C. Lambe. Agricultural Extension Service Ag-286. Dept. of Agricultural Communications, North Carolina State University, Raleigh, NC 27607. 130 pages. (1982). $5.00.



Join your local, state, and national associations. They are sources of good information.

Trade Journals Related To The Nursery And Landscape Industry

American Nurserymen
310 South Michigan Avenue
Chicago, IL 60604

Greenhouse Manager
120 St. Louis Avenue
Forth Worth, TX 76104

Nursery Business
Brantwood Publications, Inc.
Northwood Plaza Station
Clearwater, FL 33519-0360

Nursery Manager
120 St. Louis Avenue
Fort Worth, TX 76101

Nursery Product News
9800 Detroit Avenue
Cleveland, OH 44102

Sources for Books

American Nurseryman
310 S. Michigan Avenue
Chicago, IL 60604

Brantwood Publications, Inc.
Book Division
Northwood Plaza Station
Clearwater, FL 33519-0360

ISBS-Timber Press
P.O. Box 1632
Beaverton, OR 97075

Thomson Publications
P.O. Box 9335
Fresno, CA 93791

Publishers

American Nurseryman
310 S. Michigan Ave.
Chicago IL 60604

Horticultural Printers
P.O. Box 18092
Dallas, TN 75218

Prentice-Hall, Inc.
Route 9 West
Englewood Cliffs, NJ 07632

Reston Publishing Co., Inc.
11480 Sunset Hills Road
Reston VA 22090

Rodale Press, Inc.
33 E. Minor Street
Emmaus, PA 18049

Stipes Publishing Co.
P.O. Box 526
Champaign, IL 61820

Thomson Publications
P.O. Box 9335
Fresno, CA 93791

Lacebark Publications
(Whitcomb Publications)
Route 3, P.O. Box 251F
Stillwater, OK 74076

McGraw-Hill Book Co.
1221 Avenue of the Americas
New York, NY 10020

Sparks Press
P.O. Box 26747
Raleigh, NC 27611

Timber Press
9999 SW Wilshire
Portland, OR 97225

Whitcomb Publications
Route 3, Box 251F
Stillwater, OK 74076

This publication was prepared by Ken Tilt, *Extension Horticulturist.* The author is grateful to Patricia P. Cobb, *Extension Entomologist,* for her contributed article on pest management for woody ornamentals.

For more information, call your county Extension office. Look in your telephone book under your county's name to find the number.

Use pesticides **only** according to the directions on the label. Follow all directions, precautions, and restrictions that are listed. Do not use pesticides on plants that are not listed on the label.

The pesticide rates in this publication are recommended **only** if they are registered with the Environmental Protection Agency or the Alabama Department of Agriculture and Industries. If a registration is changed or cancelled, the rate listed here is no longer recommended. Before you apply **any** pesticide, check with your county Extension agent for the latest information.

Trade names are used **only** to give specific information. The Alabama Cooperative Extension Service does not endorse or guarantee any product and does not recommend one product instead of another that might be similar.

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